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Digby–Lutterworth Area

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R.M. Easton

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Foreword

Prior to 1984, only reconnaissance-level geologic information was available for the Digby–Lutterworth area. The present detailed mapping project was designed to encourage interest in mineral exploration and to evaluate mineral and land use potential. This project is part of a multiyear program to investigate the geology of the Grenville Province of southern Ontario near the town of Minden.

The Precambrian bedrock of the area hosts several metallic and nonmetallic mineral occurrences. Of the known occurrences, those of stratiform zinc and metamorphic-metasomatic molybdenum and uranium are potentially of the most economic interest. Nonmetallic occurrences in the area contain tremolite, graphite and marble; and two flagstone quarries are currently operating in gneisses near Minden.

V.G. Milne

Director
Ontario Geological Survey

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GEOLOGICAL MAP

(back pocket)

Map 2530—Precambrian geology, Digby-Lutterworth area,
scale 1:20 000

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
			LENGTH		
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
			AREA		
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
			VOLUME		
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
			CAPACITY		
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
			MASS		
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
			CONCENTRATION		
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in co-operation with the Coal Association of Canada.

Precambrian Geology Digby–Lutterworth Area

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Abstract

The Digby-Lutterworth map area lies about 140 km northeast of the city of Toronto, and covers an area of approximately 280 km².

The bedrock of the map area is Middle to Late Proterozoic in age, and is part of the Grenville Structural Province. The map area straddles the boundary between the Central Metasedimentary Belt and the Ontario Gneiss Segment of the Central Gneiss Belt. All of the Precambrian rocks have been regionally metamorphosed to upper amphibolite facies at *circa* 1070 Ma.

The map area consists of four main tectonic elements. From east to west these elements are:

1. the Glamorgan Gneiss Complex (Central Metasedimentary Belt)
2. the Denna Lake Structural Complex (Central Metasedimentary Belt)
3. the Central Metasedimentary Belt Boundary Zone
4. the Fishog subdomain (Central Gneiss Belt)

The oldest rocks in the map area are those of the Fishog subdomain, which consist of metamorphosed rocks of predominantly igneous origin. These meta-igneous rocks can be divided into six groups. In order of interpreted decreasing age, these are:

1. an older group of gneisses of mainly tonalitic and dioritic composition
2. meta-anorthosite and related rocks
3. metamorphosed monzonite and monzogranite plutons
4. metamorphosed granodiorite plutons
5. metamorphosed syenogranite sills and plutons
6. metagabbro plugs

In addition to these units, a number of hybrid rock units are found along the margins of some of the larger plutonic bodies. Several mylonite zones are also present in the Fishog subdomain.

The Glamorgan Gneiss Complex only crops out in the extreme eastern part of the map area, and represents the next oldest rock unit of the area. This complex consists of a sodic and a potassic suite, but only syenogranite gneiss of the younger potassic suite crops out in the area.

The eastern third of the map area is underlain by a heterogeneous assemblage of tectonically disrupted metasedimentary and granitoid rocks termed the Denna Lake Structural Complex. It consists of a marble tectonic breccia that contains 5 cm to 500 m sized fragments of rusty weathering siliceous clastic metasedimentary rocks, dolomite marbles, bedded calcite marbles, amphibolites, quartz arenites and a variety of granitoid and quartzofeldspathic gneisses ranging from diorite to granite in composition. The Denna Lake Structural Complex can be divided into a number of zones on the basis of dominant clast type in the marble breccias and associations of rock types. These blocks or zones constitute a "ghost" stratigraphy within the Denna Lake Structural Complex; metallic and nonmetallic mineral occurrences in the map area are associated with specific zones. Rock types found in the Denna Lake Structural Complex can be lithologically correlated with Grenville Supergroup and related intrusive rocks in the adjacent Howland area. The Denna Lake Structural Complex is probably composed of Grenville Supergroup strata deformed during the formation (or latest movement) of the Central Metasedimentary Belt Boundary Zone (CMBBZ).

The CMBBZ separates the Central Gneiss Belt (Fishog subdomain) from the Central Metasedimentary Belt (Denna Lake Structural Complex), and consists of tectonically modified gneisses, including porphyroclastic gneisses, transposed and straight gneisses, block gneisses and irregularly layered gneisses. Rocks of the CMBBZ are among the youngest rocks in the map area, based on deformation and contact relations, but the zone itself may have a prior history which has been masked by subsequent deformational events.

Late syenite and granite pegmatite dikes cut all Precambrian units in the map area except for late mafic and alkalic dikes. The mafic dikes are weakly metamorphosed and

are Late Proterozoic in age. An unusual trachyandesite dike also occurs within the CMBBZ and is Late Proterozoic in age.

Past mineral exploration in the map area has concentrated on uranium mineralization associated with late tectonic pegmatite sheets and molybdenite in marbles, and has centred on the eastern third of the map area. Most metallic and nonmetallic mineral occurrences are located in the Denna Lake Structural Complex and are associated with specific areas and lithologic units of the complex. Zinc, tremolite, dolomite, graphite and molybdenum are the commodities with the highest economic potential in the Denna Lake Structural Complex. The only mineral production in the area has come from two flagstone quarries located in the CMBBZ. Production of flagstone from the map area could be greatly expanded. Gold may also be located within the tectonites of the CMBBZ. The Fishog subdomain may host copper, nickel, gold and niobium-zirconium.

Middle Ordovician arkose, shale and limestone of the Shadow Lake and Gull River formations overlie Precambrian rocks in the southern part of the map area. Extensive sand and gravel deposits of Pleistocene age occur along the Gull River.

Résumé

La région cartographiée de Digby-Lutterworth est située à environ 140 km au nord-est de la ville de Toronto et couvre une superficie d'environ 280 km².

Dans cette région, le substratum est constituée de roches du Proterozoïque moyen à supérieur et fait partie de la province structurale de Grenville. La région se divise entre la ceinture métasédimentaire centrale et le segment ontarien de la bande de gneiss centrale. Toutes les roches du Précambrien ont été régionalement métamorphisées en facies à amphibolites supérieur, il y a environ 1070 Ma.

La région cartographiée se compose de quatre éléments tectoniques principaux. D'Est en Ouest, ce sont:

1. le complexe de gneiss de Glamorgan (ceinture métasédimentaire centrale)
2. le complexe structural du lac Denna (ceinture métasédimentaire centrale)
3. la zone frontalière de la ceinture métasédimentaire centrale
4. le sous-domaine de Fishog (ceinture de gneiss centrale)

Les roches les plus anciennes de la région cartographiée sont celles du sous-domaine de Fishog et sont composées de roches métamorphiques d'origine surtout ignée. On peut subdiviser ces roches ignées métamorphisées, en six groupes. Par ordre d'age décroissant interprété, ces groupes sont:

1. un groupe ancien de gneiss essentiellement de composition tonalitique et dioritique
2. des anorthosites métamorphisées et des roches connexes
3. des plutons de monzonite et monzogranite métamorphisées
4. des plutons de granodiorite métamorphisées
5. des filons-couches et des plutons de syénogranite métamorphisés
6. des culots de métagabbro

En plus de ces unités, un certain nombre d'unités de roches hybrides se retrouvent en bordure de certains des grands massifs plutoniques. Un certain nombre de zones à mylonitises se trouvent également dans le sous-domaine de Fishog.

Le complexe de gneiss de Glamorgan n'affleure que dans la partie extrême est de la région cartographiée et il représente la deuxième unité rocheuse la plus ancienne. Ce complexe est constitué d'une suite de gneiss sodiques et potassiques, mais seul le gneiss syénogranitique de la suite potassique, plus jeune, affleure dans la région.

Le tiers est de la région cartographiée repose sur un assemblage hétérogène de roches métasédimentaires et de granitoïdes tectoniquement disloquées, désigné sous le nom de complexe structural du lac Denna. Cet assemblage est constitué d'une brèche tectoniques à marbres qui contient des fragments de 5 cm à 500 m de roches clastiques métasédimentaires siliceuses à altération couleur de rouille, des marbres dolomitiques, des marbres calcitiques stratifiés, des amphibolites, des quartzarénites et une variété de gneiss granitoïdes et quartzofeldspathiques dont la composition va de la diorite au granite. Le complexe structural du lac Denna peut se subdiviser en un certain nombre de zones, en fonction de la lithologie clastique dominante dans les brèches à marbres ou les associations de types lithologiques. Ces blocs ou zones constituent une stratigraphie "fantôme" à l'intérieur du complexe structural du lac Denna et les gisements métallifères et non métallifères dans la région cartographiée sont associés à des zones précises. Les types de roches qui se trouvent dans le complexe structural du lac Denna peuvent être lithologiquement corrélés avec les roches intrusives du super groupe de Grenville et avec les roches associées de la région adjacente de Howland. Le complexe structural du lac Denna est probablement le résultat de la déformation des couches du super groupe de Grenville lors de la formation (ou du mouvement le plus récent) de la zone frontalière de la ceinture métasédimentaire centrale.

La zone frontalière de la ceinture métasédimentaire centrale sépare la ceinture de gneiss central (sous-domaine de Fishog) de la ceinture central (complexe structural du lac Denna). Elle est constituée de gneiss modifiés tectoniquement, dont des gneiss por-

phyroblastiques, des gneiss transposé des gneiss ordinaires, des gneiss à blocs et des gneiss irrégulièrement rubannés. Les roches de la zone frontalière de la ceinture métasédimentaire centrale se placent parmi les plus jeunes de la région cartographiée, d'après les relations de déformation et de contact, mais la zone elle-même pourrait avoir une histoire plus ancienne masquée par des déformations postérieures.

Toutes les unités du Précambrien de la zone cartographiée sont recoupées de dykes tardifs pegmatitiques de composition syénitiques et granitiques, à l'exception des dykes tardifs mafiques et alcalins. Les dykes mafiques sont faiblement métamorphisés et sont d'age tardi-Proterozoique. On observe également un dyke inhabituel de composition trachyandésitique dans la zone frontalière de la ceinture métasédimentaire centrale d'age tardi-Proterozoique.

L'exploration minière, concentrée jusqu'ici sur les minéralisations d'uranium, associées aux pegmatites tardi-tectoniques, et de molybdéne, associées aux marbres, était axée dans le tiers est de la région cartographiée. La plupart des gisements de minéraux métallifères et non métallifères se trouvent situés dans le complexe structural du lac Denna et sont associés à des zones et unités lithologiques précises du complexe. Les minéraux offrant les meilleures potentiel pour l'exploration dans le complexe structural du lac Denna sont le zinc, la trémolite, la dolomite, le graphite et le molybdène. La seule production minière dans la région provient de l'exploitation de deux carrières de dalles dans la zone frontalière de la ceinture métasédimentaire centrale. La production de dalles dans la région cartographiée pourrait être fortement accrue. Il pourrait également y avoir de l'or dans les noches tectonisées de la zone frontalière de la ceinture métasédimentaire centrale. Le sous-domaine de Fishog pourrait en outre contenir des minéralisations de cuivre, de nickel, d'or et de niobium-zirconium.

Les arkoses, les schistes argileux et les calcaires de l'Ordovicien moyen des formations du lac Shadow et de la rivière Gull reposent sur des roches précambriennes dans la partie sud de la région cartographiée. On trouve des dépôts importants de sable et de gravier remontant au Pléistocène le long de la rivière Gull.

Precambrian geology, Digby-Lutterworth area, by R.M. Easton, Ontario Geological Survey, Report 269, 86p. Published 1990. ISBN 0-7729-5999-4.

Introduction

The Digby–Lutterworth map area lies between latitudes 44°45′00″ and 44°52′30″N and longitudes 78°45′00″ and 79°00′00″W, in the counties of Haliburton and Victoria. The area covers about 280 km², is located 140 km northeast of the city of Toronto, and includes parts of Digby, Laxton, Longford, Lutterworth and Somerville townships. The northeast corner of the map area lies 5 km south of the town of Minden (Figure 1).

No metallic mineral production has taken place in the area. Two small stone quarries were operating in the map area in 1984 and produced flagstone for ornamental and building purposes. Although no metallic mineral production has been reported in the map area, the Paxton Mine located 5 km east of the map area produced iron ore in the 1890s, and the Horscroft Mine located 5 km south of the map area produced molybdenum ore in 1916. Sporadic staking has gone on, and a number of small metallic and radioactive mineral occurrences have been found and explored.

Access

The area can be reached by Highway 35 from Lindsay and Peterborough to the south, and by Highway 503 from Orillia to the west and Bancroft to the east. Highway 35 parallels the eastern boundary of the map area, and along with Haliburton County Road 2, provides access to the eastern third of the map area. Highway 503 parallels the southern boundary of the map area, and provides limited access to the western two-thirds of the map area. The remainder of the map area is accessible only by canoe through Head, Fishog and Crooked lakes, or by float-equipped aircraft. All lakes in the area are small. Some of the larger lakes are surrounded by cottage sites, and can be reached by secondary roads. Services are available in the village of Norland, 3 km south of the map area, and in the town of Minden, located 5 km north of the map area on Highway 35.

Physiography

Relief in the map area is about 75 m. The altitude gradually increases from about 275 m above sea level in the southern part of the map area to about 350 to 375 m above sea level in the north. In general, relief is more subdued in the areas underlain by granitic and monzonitic rocks in the Fishog subdomain. Relief is more pronounced along the Gull River valley and in the area underlain by the Denna Lake Structural Complex. In the Denna Lake Structural Complex, relief is lowest in areas underlain by calcite marble breccia and along contacts between the larger domains (blocks?) within the complex; and highest in areas underlain by more resistant granite, quartz arenite and dolomite. In some instances, individual hills within the Denna Lake Structural Complex may represent large blocks of resistant rock within the marble breccia.

Most areas underlain by Paleozoic rocks and carbonate metasedimentary rocks have been cleared in the past for agriculture. The lowest areas in the map area are located along Head Lake and Head Creek, and along the Gull River.

Most of the eastern third of the map area is drained by the Gull River system. The northern part of the map area also drains into the Gull River system via Victoria, Sheldon and Black lakes. The western and central parts of the map area drain into Head Creek via Smudge Lake, and into Head Lake and Head Creek via Crooked, Long and Fishog lakes. Scrabble, Clear, Cranberry and Red Boat lakes also drain into Head Lake via Fishog Lake. Head Creek drains into Balsam Lake and from there into the Trent River system. The Gull River also drains south into the Trent River system.

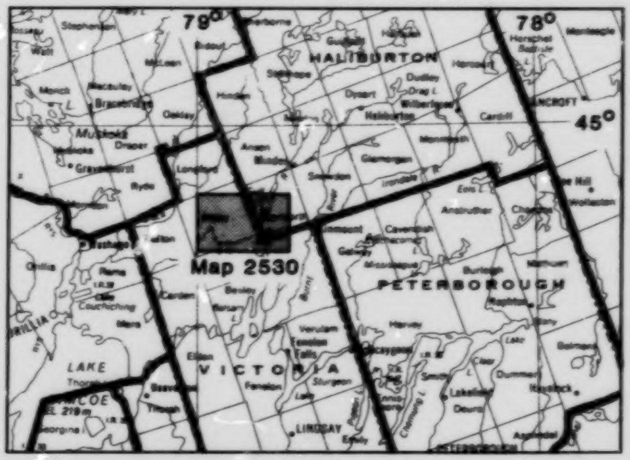


Figure 1. Key map showing the location of the Digby–Lutterworth area.

The distribution of rock outcrop is variable. Bedrock exposures are abundant in the central and western parts of the map area which are underlain by granitoid and gneissic rocks; these rocks locally constitute up to 80 percent of the total outcrop in any area. Less exposure is found in the eastern part of the map area, both in the Denna Lake Structural Complex which is made up of predominantly carbonate rocks, and along the western shore of Gull Lake where thick accumulations of till are present. Here, 15 to 40 percent of the area consists of outcrop. Large swamps are common along the Paleozoic–Precambrian unconformity in the southern part of the map area. In the central part of the map area, many large swamps also occur, mainly due to beaver activity. Many low outcrops are present in cultivated and open fields in the southern and eastern parts of the area, and human activity has in part prevented some of these outcrops from being overgrown. Glaciofluvial deposits are common along the Gull River system, and mantle older topography.

There is a reasonable correlation between geology and topography in the map area, in part because of the contrast in resistance to erosion shown between granitic gneisses and the mafic gneisses and carbonate rocks. In the Denna Lake Structural Complex, topography is influenced by the distribution of resistant rock types in this marble breccia zone. In addition, the dips of most geologic units in the area are shallow, and hence small differences in topography closely reflect rock type.

Previous Geological Work

Previous geological work in the map area was of limited extent and detail. Some of the first work was a reconnaissance survey of the Haliburton–Bancroft area by Adams and Barlow (1910) for the Geological Survey of Canada. In this and subsequent surveys, the map area was at the margin of the main area of interest and received only minor attention. Satterly (1943) examined part of the area during the course of the preparation of 1:126 720 scale compilation maps for the Haliburton–Bancroft region, and made some improvements to the map of Adams and Barlow (1910). Schwerdtner and Mawer (1982) did a reconnaissance survey of the Precambrian geology of the Lake Simcoe area, including the map area, but only made a coarse subdivision of the area into orthogneiss, paragneiss and marble. Caley and Liberty (1952) and Liberty (1969) have studied in detail the Paleozoic rocks adjacent to, and within the southern part of, the map area.

The Howland area immediately east of the map area was mapped by the author in 1983 (Easton and Bartlett 1984; Easton 1987a). The area to the north of the map area, particularly the CMBBZ, has been examined by Davidson et al. (1984) and Hanmer and Ciesielski (1984). Subsequent to the completion of mapping of the Digby–Lutterworth area in 1984, in 1985 and 1986, mapping of the adjacent Anson area directly to the north (Easton 1987c) and the Lochlin area to the northeast (Easton 1987b) was completed. Results of mapping in the Anson area to the north (Easton 1987c) are in agreement with the results presented in this report. A preliminary 1:50 000 scale geological compilation map of the Minden area (NTS 31 D/15), which includes the Digby–Lutterworth area, as well as the results of mapping in the Anson, Howland and Lochlin areas, was released in 1988 by the Ontario Geological Survey (Easton 1988).

A field trip guidebook covering the eastern third of the map area was published in 1984 (Easton et al. 1984). A field trip guide to the Minden–Dorset region along Highway 35, which includes stops in the Digby–Lutterworth area, was published in 1987 (Easton 1987d).

C. Kaszycki (1985) has described the Quaternary geology of the Minden (31 D/15) and Haliburton (31 E/12) topographic sheets; however, this work was released after completion of mapping in the Digby–Lutterworth area and preparation of this report. Finamore and Bajc (1983) have mapped the Quaternary geology of the Fenelon Falls area due south of the map area at 1:50 000 scale. Henderson (1973) discussed the Quaternary geology of the area in general terms.

Present Geological Survey

Map 2530 (back pocket), at a scale of 1:20 000, presents the results of the geological survey carried out by the author and his assistants during the summer of 1984. Preliminary maps P.2951 and P.2952 (Easton et al. 1985a, 1985b), at a scale of 1:15 840, were released in 1985 and a preliminary report on the geology of the area was presented in the 1984 Summary of Field Work (Easton and Van Kranendonk 1984). A field trip guide covering the eastern third of the map area (Easton et al. 1984) was released in 1984 by the Friends of the Grenville Organization.

Aerial photographs at a scale of 1:15 840 (1 inch to 1/4 mile) were supplied by the Cartography Division, Ontario Ministry of Natural Resources, and were used for mapping control. Acetate overlays were used to record data collected on traverses which were run by the pace and compass method. Information from mapping was plotted on Forest Resource Inventory Base Map 447784 at a scale of 1:15 840. Recent information with respect to roads, buildings, powerlines and shoreline features were added to the base map. The geology was not tied to surveyed lines. Traverses were not spaced at regular intervals, but were designed to include as many of the major outcrop areas as possible, particularly in areas of complex geology and along contacts between major rock units.

Acknowledgments

The writer was ably assisted in the mapping during the field season by senior assistants M. Van Kranendonk and D. Sanderson. Assistance was also provided by R. Kilpatrick and P. Roy, junior assistants.

The assistance of various staff members of the Minden district office of the Ontario Ministry of Natural Resources is also greatly appreciated. Many landowners in the area kindly granted us permission to inspect their properties, and their assistance is gratefully acknowledged. Longford Reserve Limited kindly granted permission for the geological survey to be carried out across their extensive land holdings in Longford Township. Discussions with J. Van Berkel, W.M. Schwerdtner, M. Van Kranendonk and S. Hanmer proved very useful.

Except where otherwise stated, all chemical analyses that appear in this report were done by the Geoscience Laboratories Section, Ontario Geological Survey, Toronto. Locations of analyzed samples are given in Figure 28.

Terminology

In order to avoid confusion, a number of terms used in the discussion of the general geology of the map area are outlined below.

PRECAMBRIAN TIME SCALE

The Precambrian time scale as subdivided by Palmer (1983) is used. Precambrian time is divided into two eons: the Archean (older than 2500 Ma) and the Proterozoic (between 2500 and 570 Ma). The Proterozoic is divided into three eras: Early (2500 to 1600 Ma), Middle (1600 to 900 Ma), and Late (900 to 570 Ma).

ROCK CLASSIFICATION

The terminology used here for all plutonic rocks in the area follows the recommendations of Streckeisen (1976).

The classification of marbles is based on CaO:MgO ratio, after Storey and Vos (1981), as indicated below in Table 1. It is possible to apply this classification scheme in the field reliably using dilute hydrochloric acid tests.

The term "trondhjemite" is used in the sense of Barker (1979). A trondhjemite is a leucocratic tonalite in which the plagioclase feldspar is oligoclase or andesine; quartz forms more than 20 percent of the rock, there is less than 10 percent alkali feldspar, and the colour index is 10 or less. This definition is similar to that of Streckeisen (1976).

For metamorphic rocks, mineral prefixes are listed in order of relative abundance, starting with the least abundant first. The following conventions are used regarding descriptive adjectives. A "gneissic granite" is a meta-igneous rock of granitic composition. A "granitic gneiss" or a "gneiss of granitic composition" may be either a meta-igneous or a metasedimentary rock. Similarly, a "tonalitic gneiss" is a gneiss having the modal composition of a tonalite, but may be of either meta-igneous or metasedimentary origin. A "gneissic meta-arkose" is a metasedimentary gneiss of granitic composition.

For tectonites in the map area, the terminology used is that of Davidson et al. (1982), as formally outlined by Hanmer and Ciesielski (1984). These terms include "transposed gneiss", "porphyroclastic gneiss", "straight gneiss", and "block gneiss". These terms will be defined in greater detail in the section entitled "Rocks in the Central Metasedimentary Belt Boundary Zone".

The term "metamorphic grade" is used in the case where bulk-rock composition or other factors prevent a more detailed assignment of metamorphic conditions. The metamorphic grade scheme used in this report is shown in Figure 2. Where metamorphic conditions can be outlined more precisely, the metamorphic facies terminology of Turner (1981) is used.

FOLIATION, SCHISTOSITY, GNEISSOSITY, CLEAVAGE

The term "foliation" is used to describe all types of megascopically recognizable structural surfaces of metamorphic origin (Turner and Weiss 1963). Several distinguishable types of foliation include compositional layering, preferred orientation of mineral grains, and localized slip features. Gneissosity and schistosity are the most common varieties of foliation in the map area. Schistosity is a planar structure in a metamorphic rock which arises from an abundance of preferentially oriented grains, especially micas. Schistosity is accompanied by a fissility in the rock, and is best developed in rocks rich in micaceous minerals. The term "gneissosity" denotes layering of metamorphic origin, defined by the alternation of layers, streaks, or lenticles of contrasting mineralogy or texture. The streaks or lenticles may be discontinuous. The term "cleavage" denotes a parting in the rock resulting from the parallel growth of micaceous or elongated minerals in fine-grained rocks.

LAYERING THICKNESS TERMS

Layering thickness terms used in this report are listed in Table 2.

TABLE 1. CLASSIFICATION OF MARBLES BASED ON CaO:MgO RATIO, AFTER STOREY AND VOS (1981), DIGBY–LUTTERWORTH AREA.

Marble Type		Range in Value for CaO:MgO	MgO (%)
Dolomite marble		1.40–1.67	19.7–21.8
Magnesian marble	Calcitic dolomite marble	1.67–3.95	10.9–19.7
	Dolomitic calcite marble	3.95–24.40	2.2–10.9
Calcite marble		>24.40	0.0–2.2

TABLE 2. LAYERING THICKNESS TERMS USED IN THIS REPORT.

Very thinly layered	< 3 cm
Thinly layered	3 to 10 cm
Medium layered	10 to 30 cm
Thickly layered	30 to 100 cm (1 m)
Very thickly layered	1 to 3 m
Extremely thickly layered	> 3 m

These terms correspond to bedding thickness terms used for bedded rocks.

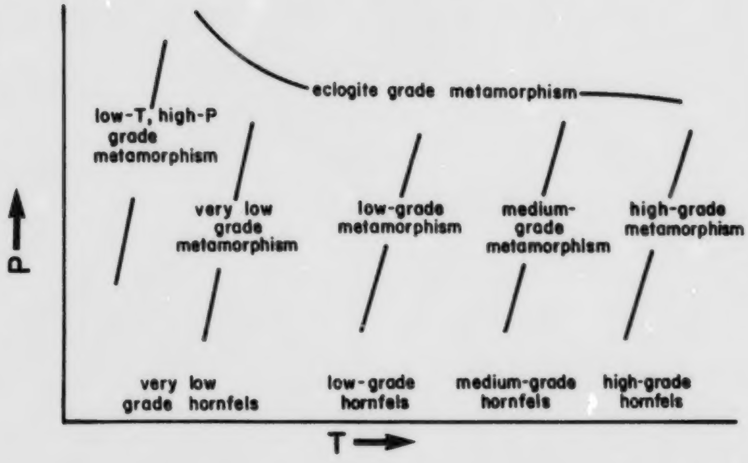

eclogite grade metamorphism
low-T, high-P grade metamorphism
very low grade metamorphism
low-grade metamorphism
medium-grade metamorphism
high-grade metamorphism
very low grade hornfels
low-grade hornfels
medium-grade hornfels
high-grade hornfels
P
T

Figure 2. Metamorphic grade classification scheme used in this report.

General Geology

The Digby–Lutterworth area is underlain mainly by Precambrian rocks of the Grenville Structural Province. Precambrian rocks in the map area are of Middle to Late Proterozoic age, and straddle two major tectonic zones of the Grenville Province: the Central Metasedimentary Belt (CMB) (subzone IV-A of Wynne-Edwards 1972) to the east, and the Central Gneiss Belt (CGB) (Ontario Gneiss Segment of Wynne-Edwards 1972) to the west. Deformed rocks in the Gull Lake area form the boundary zone between the two terranes (Figure 3) and the boundary zone has been termed the Central Metasedimentary Belt Boundary Zone (Davidson et al. 1984).

The Precambrian rocks may be divided into four main groups, which also correspond to major tectonic features (Figure 3). In order of interpreted decreasing age, these are:

1. The Fishog subdomain (CGB) underlies the western two-thirds of the map area, and consists of a metamorphosed igneous terrane. These rocks correspond in part to the Algonquin Batholith of Schwerdtner and Lumbers (1980) and Lumbers (1982).
2. The Glamorgan Gneiss Complex (CMB) (Easton 1987a) occurs along the eastern boundary of the map area, and may be the basement to the Grenville Supergroup.
3. The Denna Lake Structural Complex (CMB) (Easton 1987a) consists of tectonically disrupted Grenville Supergroup rocks, and underlies the eastern third of the map area.
4. The Central Metasedimentary Belt Boundary Zone (CMBBZ) separates the Fishog subdomain and the Denna Lake Structural Complex, and is a zone of tectonically disrupted gneisses. Late tectonic pegmatite sheets and mafic dikes cut all of the above units. Flat-lying Middle Ordovician rocks unconformably overlie the Precambrian succession in the southern part of the map area.

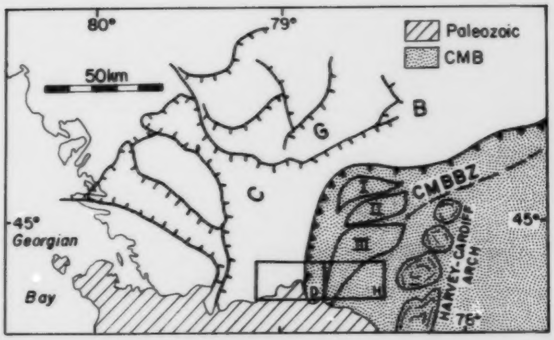


Figure 3. Regional geologic setting of the Digby–Lutterworth area (area "D"; adjoining area "H" is the Howland area). Hatched line represents domain and subdomain boundaries; line with filled triangles represents thrust faults; roman numerals represent areas of tonalitic gneiss complexes; CGB = Central Gneiss Belt.

The general stratigraphic succession of rocks in the area is given in Table 3. Figure 4 is a generalized geologic map of the area, simplified from Map 2530 (back pocket). Figure 4 also shows the location of mineral occurrences within the map area. Figure 5 shows the major tectonic elements of the Digby–Lutterworth area, as well as important geographic names.

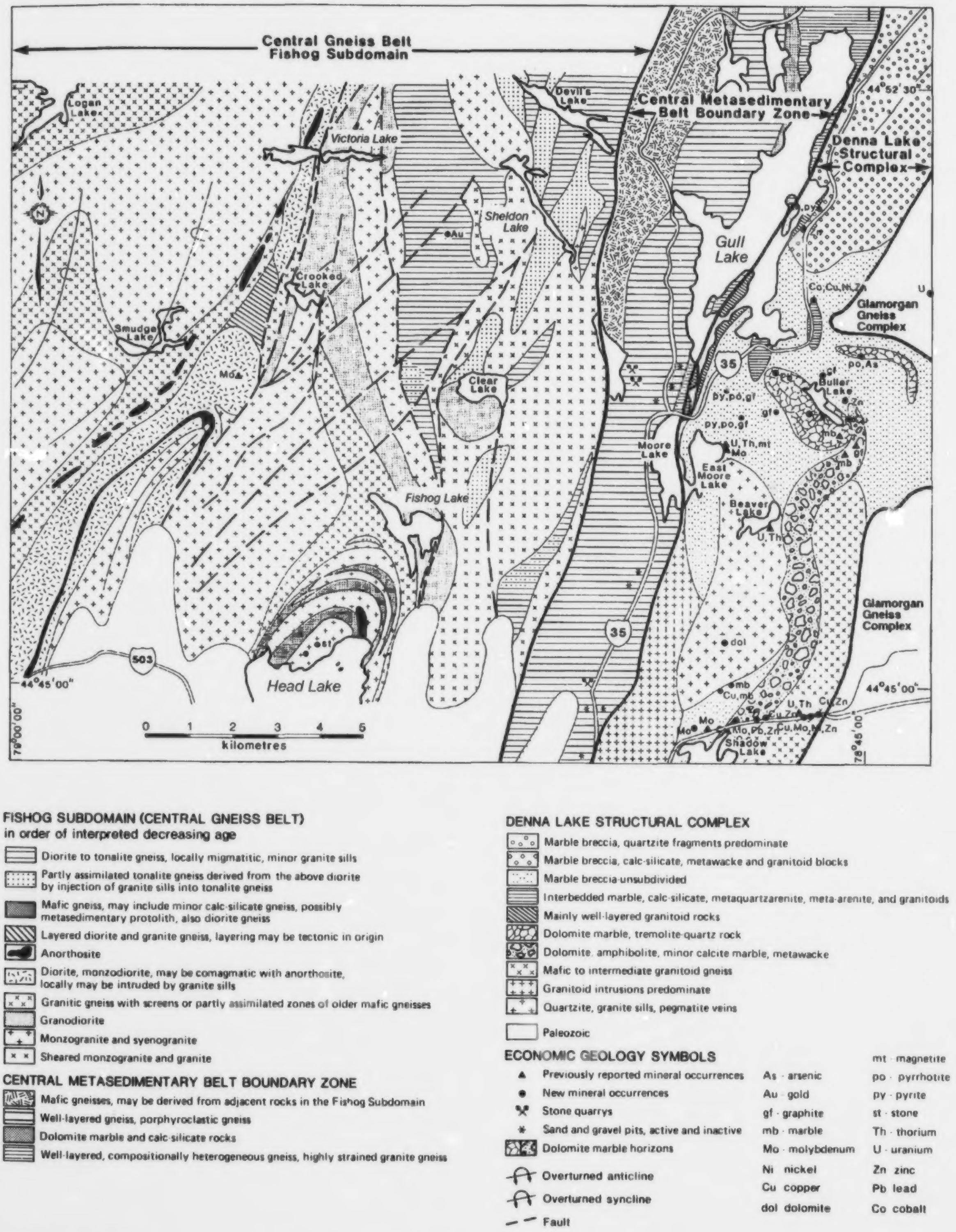
The oldest rocks in the map area are those of the Fishog subdomain, which consist of metamorphosed rocks of predominantly igneous origin. These rocks can be subdivided into six groups on the basis of lithology, structure, and crosscutting relationships. In order of interpreted decreasing age these are:

1. an older group of gneisses of mainly tonalitic and dioritic composition
2. meta-anorthosite and related rocks
3. metamorphosed monzonite and monzogranite plutons
4. metamorphosed granodiorite plutons
5. metamorphosed syenogranite sills and plutons
6. metagabbro plugs

In addition, a number of hybrid rock units are found along the margins of some of the larger plutonic bodies. Several mylonite zones are also present in the Fishog subdomain.

Gneisses of the older group are found mainly near Sheldon Lake, in the Head Lake oval (*see description under* "Fishog Subdomain Anorthositic Rocks") and in the vicinity of Smudge Lake (Figures 4 and 5). North of Scrabble Lake, this unit consists of tonalitic and dioritic migmatitic gneisses, which are probably the oldest rocks in the Fishog subdomain. These rocks have a granodioritic leucosome phase which is absent from other gneisses of the older group. In the Head Lake area, gneisses of the older group consist of calc-silicate and related gneisses of possible metasedimentary parentage interlayered with diorite and other mafic gneisses. These gneisses have been intruded by sills and sheets of anorthosite and related rocks, monzonitic rocks and syenogranite. In the Smudge Lake area, and north of Fishog Lake, gneisses of the older group occur as well-layered dioritic gneisses present as slivers between the monzonitic and granitic plutons that underlie most of the Fishog subdomain. The rocks of the older gneiss group are characterized by their overall mafic composition, their intrusion by all later meta-igneous rocks, and the fact that fold structures within these rocks (for example, the Head Lake oval and Head River syncline (Figure 5) influence the location of later igneous events.

The anorthosite group of rocks consists of anorthosite and anorthositic gabbro, as well as a group of diorite


Central Gneiss Belt
Fishog Subdomain
Central Metasedimentary Belt Boundary Zone
Denna Lake Structural Complex
Glamorgan Gneiss Complex
Glamorgan Gneiss Complex
44°52'30"
44°45'00"
44°45'00"
79°00'00"
78°45'00"
Logan Lake
Victoria Lake
Devil's Lake
Sheldon Lake
Crooked Lake
Smudge Lake
Clear Lake
Fishog Lake
Head Lake
Gull Lake
Moore Lake
East Moore Lake
Beaver Lake
Buller Lake
Shadow Lake
35
35
503
N
Au
Mo
py,po,gf
py,po,gf
gf
U,Th,mt
Mo
U,Th
Co,Cu,Ni,Zn
U
po,As
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Zn
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dol
mb
Cu,mb
U,Th
Cu,Zn
Cu,Zn
Mo
Mo
Mo,Pb,Zn
Cu,Mo,Ni,Zn
py
0 1 2 3 4 5
kilometres
FISHOG SUBDOMAIN (CENTRAL GNEISS BELT)
in order of interpreted decreasing age
Diorite to tonalite gneiss, locally migmatitic, minor granite sills
Partly assimilated tonalite gneiss derived from the above diorite by injection of granite sills into tonalite gneiss
Mafic gneiss, may include minor calc-silicate gneiss, possibly metasedimentary protolith, also diorite gneiss
Layered diorite and granite gneiss, layering may be tectonic in origin
Anorthosite
Diorite, monzodiorite, may be comagmatic with anorthosite, locally may be intruded by granite sills
Granitic gneiss with screens or partly assimilated zones of older mafic gneisses
Granodiorite
Monzogranite and syenogranite
Sheared monzogranite and granite
CENTRAL METASEDIMENTARY BELT BOUNDARY ZONE
Mafic gneisses, may be derived from adjacent rocks in the Fishog Subdomain
Well-layered gneiss, porphyroclastic gneiss
Dolomite marble and calc-silicate rocks
Well-layered, compositionally heterogeneous gneiss, highly strained granite gneiss
DENNA LAKE STRUCTURAL COMPLEX
Marble breccia, quartzite fragments predominate
Marble breccia, calc-silicate, metawacke and granitoid blocks
Marble breccia-unsubdivided
Interbedded marble, calc-silicate, metaquartzarenite, meta-arenite, and granitoids
Mainly well-layered granitoid rocks
Dolomite marble, tremolite-quartz rock
Dolomite, amphibolite, minor calcite marble, metawacke
Mafic to intermediate granitoid gneiss
Granitoid intrusions predominate
Quartzite, granite sills, pegmatite veins
Paleozoic
ECONOMIC GEOLOGY SYMBOLS
▲ Previously reported mineral occurrences
● New mineral occurrences
Stone quarrys
* Sand and gravel pits, active and inactive
Dolomite marble horizons
Overturned anticline
Overturned syncline
Fault
As - arsenic
Au - gold
gf - graphite
mb - marble
Mo - molybdenum
Ni nickel
Cu copper
dol dolomite
mt - magnetite
po - pyrrhotite
py - pyrite
st - stone
Th - thorium
U - uranium
Zn zinc
Pb lead
Co cobalt

Figure 4. Simplified geologic map of the Digby–Lutterworth area.

TABLE 3. TABLE OF LITHOLOGIC UNITS FOR THE DIGBY-LUTTERWORTH AREA.

PHANEROZOIC

CENOZOIC

QUATERNARY

RECENT

Organic swamp and alluvial deposits

PLEISTOCENE

Outwash deposits, sand, silt, clay and till

Unconformity

PALEOZOIC

MIDDLE ORDOVICIAN

GULL RIVER FORMATION (SIMCOE GROUP)

Limestone

SHADOW LAKE FORMATION (BASAL GROUP)

Calcareous arkose, red and green shales

Unconformity

PRECAMBRIAN

LATE PROTEROZOIC

FELSIC INTRUSIVE ROCKS

Intermediate to felsic alkaline intrusive rocks,

Unmetamorphosed dikes and sills

Intrusive Contact

MAFIC INTRUSIVE ROCKS

Weakly metamorphosed diabase dikes and sills

Intrusive Contact

MIDDLE TO LATE PROTEROZOIC

LATE TO POSTTECTONIC FELSIC INTRUSIVE ROCKS

POTASSIC PEGMATITIC INTRUSIVE ROCKS

Syenite to syenogranite pegmatite dikes and sills

Intrusive Contact

FELSIC INTRUSIVE ROCKS

Weakly deformed syenogranite plutons

Intrusive Contact

CENTRAL METASEDIMENTARY BELT BOUNDARY ZONE (CMBBZ)

Moderately to highly disrupted gneisses, generally of unknown protolith, with varied composition ranging from amphibolite to granite, locally containing porphyroclastic and well-transposed gneisses

Fault Contact?

DENNA LAKE STRUCTURAL COMPLEX (METAMORPHOSED TECTONIC BRECCIA)

Fist- to house-sized and larger, round to sub-round blocks of amphibolite, gabbro, diorite, granodiorite, syenogranite, cataclastic syenogranite and syenite pegmatite, migmatite, paragneiss, arkose, wacke, quartz arenite, dolomite and calcite marble in a medium-grained calcite matrix.

Fault Contact?

MIDDLE PROTEROZOIC

GLAMORGAN GNEISS COMPLEX

POTASSIC SUITE (CREGO LAKE LITHODEME)

Monzogranite and syenogranite gneiss

SODIC SUITE (not represented in map area)

Fault Contact

TABLE 3. CONTINUED.

CENTRAL GNEISS BELT (FISHOG SUBDOMAIN)

MAFIC INTRUSIVE ROCKS

Gabbro plugs

Intrusive Contact?

Fault Contact

MYLONITIC ROCKS

Proto– and ultramylonite

Fault Contact

FELSIC INTRUSIVE ROCKS

LAYERED GRANITE GNEISS (HYBRID GNEISS)

Layered monzogranite to syenogranite gneiss with 25% to 50% thin layers of fine–grained mafic gneiss of unknown origin

Intrusive Contact

MASSIVE GRANITE GNEISS

Medium– to coarse–grained syenogranite gneiss

Intrusive Contact

HYBRID GNEISSES

Hybrid gneisses derived from massive granite gneiss and dioritic to tonalitic migmatitic gneiss of the 'older' gneiss group

Intrusive Contact

INTERMEDIATE INTRUSIVE ROCKS

Granodiorite gneiss

Intrusive Contact

MONZONITE SUITE

Monzonite gneiss

Intrusive Contact

Intermediate to monzonitic gneiss

Intrusive Contact

ANORTHOSITE SUITE

Felsic intrusive rocks spatially associated with anorthositic and related rocks, including metacrystic granitic rocks, quartz diorite gneiss; mafic to intermediate, quartz–poor intrusive rocks including quartz diorite gneiss, monzodiorite, quartz monzonite; anorthosite, including anorthosite, anorthositic gabbro and leucogabbro

MIGMATITIC ROCKS

Migmatitic gneiss derived from layered calc–silicate gneiss, diorite and other mafic gneisses, monzonite suite intrusive rocks and massive granite gneiss

Intrusive Contact

OLDER GNEISSES

DIORITIC AND OTHER MAFIC GNEISSES

Intrusive Contact

LAYERED CALC–SILICATE GNEISSES

Unconformity?

DIORITIC TO TONALITIC MIGMATITIC GNEISSES

LAYERED CALC–SILICATE GNEISSES

Unconformity?

DIORITIC TO TONALITIC MIGMATITIC GNEISSES

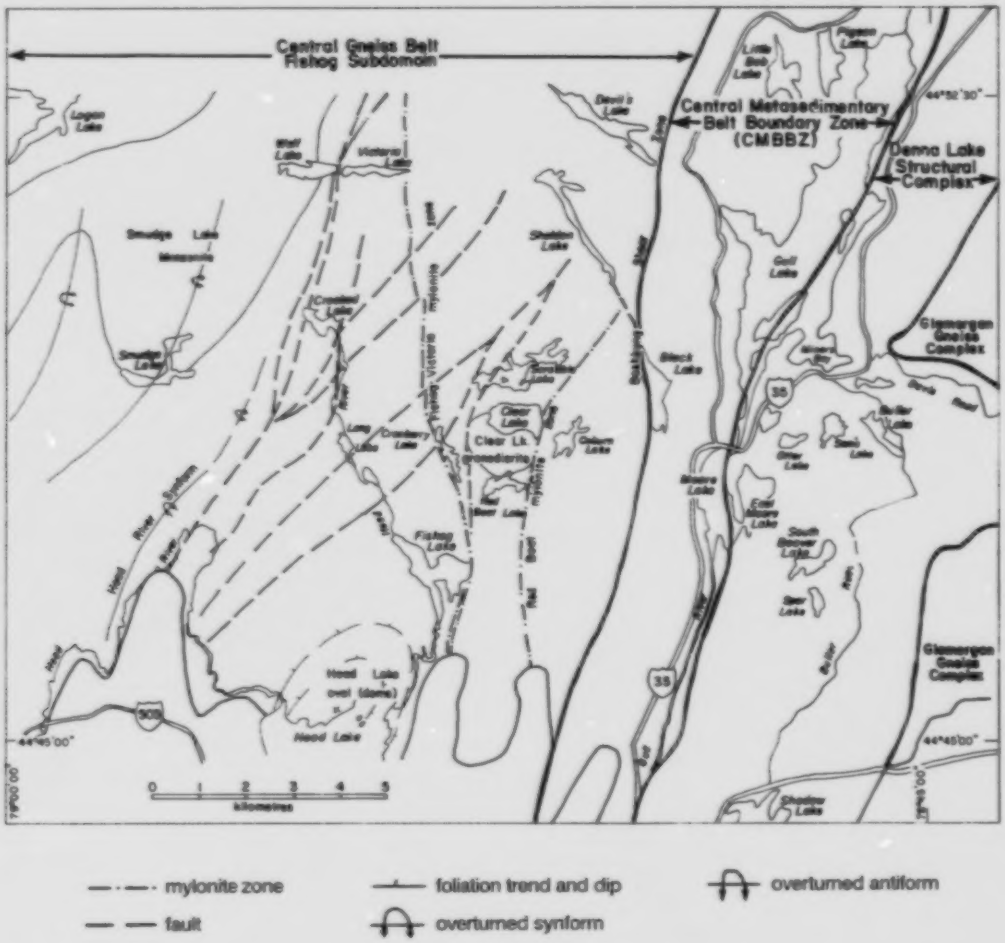
Central Gneiss Belt
Fishog Subdomain
Logan Lake
Wolf Lake
Victoria Lake
Smudge Lake
Monzonite
Smudge Lake
Crooked Lake
Long Lake
Cranberry Lake
Victoria mylonite
Clear Lake
Clear Lk. granodiorite
Bear Lake
Fishog Lake
Head River Synform
Head River
Head Lake oval (dome)
Head Lake
503
44°45'00"
78°00'00"
0 1 2 3 4 5
kilometres
Devil's Lake
Little Bob Lake
Pigeon Lake
44°52'30"
Central Metasedimentary Belt Boundary Zone (CMBBZ)
Denna Lake Structural Complex
Gull Lake
Black Lake
Glamorgan Gneiss Complex
35
Moore Lake
South Beaver Lake
Burnt River
Shadow Lake
44°45'00"
mylonite zone
fault
foliation trend and dip
overturned synform
overturned antiform

Figure 5. Major tectonic elements and geographic names, Digby–Lutterworth area.

to quartz monzodiorite and monzonitic rocks which are spatially and temporally associated with the anorthosites. All of these rocks may have been part of an igneous complex at one time. Three major sheets of anorthosite are present in the map area:

1. in the Head Lake oval
2. as a boudinaged sheet southeast of Smudge Lake
3. as a large folded sheet southeast of Smudge Lake roughly paralleling the Head River (Figures 4 and 5)

The Head River sheet was probably intruded before folding. The boudinaged sheet was intruded prior to intrusion of the monzonite suite rocks, as blocks of anorthosite are found in intrusion breccias and injection migmatites along the margin of the Smudge Lake monzonite. Anorthosites in the Head Lake oval were also intruded before the intrusion of granite sills into the oval. The anorthosites and related rocks correspond to the mafic anorthosite suite of Lumbers (1982). The anorthosite sheets in the map area are unique in their lack of associated gabbro and ultramafic rocks and no mylonitic or high strain zones are found adjacent to the anorthosite sheets in the map area.

Monzonitic to monzogranitic plutons intrude rocks of the older diorite and anorthosite groups in the western third of the map area. These plutons are located west and north of Smudge Lake, are compositionally variable, and have xenolith-rich margins that are several hundred metres in width. Migmatitic gneisses representing injection migmatites, intrusion breccias, and other partly assimilated country rocks are also present adjacent to these plutons. In addition, the monzonitic plutons were either intruded into, or deformed with, the major fold structures present in the western part of the map area. These rocks would correspond to the monzonitic group of the anorthosite suite of Lumbers (1982). Together, the anorthosite group and monzonite group rocks of the Digby–Lutterworth area form part of the Algonquin Batholith of Lumbers (1982).

Massive to weakly foliated granodiorite plutons, which may be roughly lenticular in form, intrude the older dioritic rocks. These plutons are more common in the eastern half of the Fishog subdomain, particularly north of Fishog and Red Boat lakes. In turn, these granodiorite plutons have been intruded by syenogranite sills and plutons which underlie about half of the Fishog subdomain, particularly the central and eastern parts of the domain.

Two late gabbroic plugs are present in the Fishog subdomain and apparently indicate the waning of magmatic activity in the zone. High strain zones and mylonitic rocks are locally present within the Fishog subdomain and affect all of the rock types within the Fishog subdomain except the late gabbroic plugs. The two largest mylonite zones are the Fishog–Victoria lakes and the Red Boat Lake mylonite zones (Figure 5).

The Glamorgan Gneiss Complex has been described in detail by Easton (1987a), and crops out only in the extreme eastern part of the map area. Syenogranite gneiss of the Crego Lake Lithodeme is the only unit of the Glamorgan complex that outcrops in the map area.

The eastern third of the map area is underlain by a heterogeneous assemblage of tectonically disrupted strata, and is termed the Denna Lake Structural Complex. It consists of a marble tectonic breccia that contains fragments ranging in size from tens of centimetres to hundreds of metres. The fragments are composed of rusty weathering siliceous metasediments, tremolite-bearing dolomite marbles, bedded calcite marbles, amphibolite, quartz arenites and a variety of granitoid rocks and quartzofeldspathic gneisses (ranging from diorite to granite in composition), and show varying degrees of tectonic disruption. The Denna Lake Structural Complex is characterized by aeromagnetic and gamma ray spectrometric anomalies and is the site of most metallic mineral occurrences in the map area. It is also an area of pegmatite dike swarms of syenite and syenogranite composition. The pegmatite dikes may be deformed or undeformed. Despite the tectonic disruption that the Denna Lake Structural Complex has undergone, it is possible to subdivide the complex into a number of zones or blocks on the basis of dominant clast type in the marble breccias, or of associations of lithologic types (Figure 4). These blocks or zones constitute a "ghost" stratigraphy within the complex. It is significant that metallic and nonmetallic mineral occurrences within the complex are commonly restricted to specific blocks or zones. Rock types present within the Denna Lake Structural Complex can be lithologically correlated with Grenville Supergroup strata in the adjacent Howland map area (Easton 1987a). The Denna Lake Structural Complex is probably composed of Grenville Supergroup strata deformed during the formation, or by the latest movement of, the Central Metasedimentary Belt Boundary Zone.

The Central Metasedimentary Belt Boundary Zone (CMBBZ) separates the Central Gneiss Belt (Fishog subdomain in the map area) from the Central Metasedimentary Belt (Denna Lake Structural Complex in the map area: Figures 3 and 4). Rocks within this zone have been tectonically modified, and include a number of tectonites, including porphyroclastic gneisses, transposed gneisses, block gneisses and straight gneisses (Hanmer and Ciesielski 1984). The CMBBZ has been divided into a number of mappable units, based on overall composition, layering characteristics, degree of tectonic disruption, grain size, texture, and in some cases, distinctive mineralogy.

The CMBBZ varies from a zone of well-layered, highly strained granite and granitoid gneisses of indeterminate protolith in the east, to a zone of highly disrupted rocks in the west. Within this latter zone are found the porphyroclastic gneisses of Davidson et al. (1982). The protolith of many rocks in this zone is indeterminate, although some marble and calc-silicate units are present.

In the northern part of the CMBBZ, a belt of disrupted and strained mafic gneisses occur which are probably derived from mafic gneisses in the adjacent Fishog subdomain. In the south, granite layers become more abundant in the western part of the CMBBZ, and in part, this may reflect the presence of granites in the adjacent Fishog subdomain.

The thinness of the CMBBZ in the southern part of the map area may be due to structural onlap of the Denna Lake Structural Complex (Figure 4) or a slightly deeper level of erosion.

Late syenite and granite pegmatite dikes cut all units in the map area, except the unconformably overlying Paleozoic strata, and late mafic and alkalic dikes. The mafic dikes are weakly metamorphosed and are of Late Proterozoic age. An unusual trachyandesite dike also occurs within the CMBBZ, and may be of Late Proterozoic or Early Cambrian age.

Paleozoic strata of the Basal and Simcoe groups of Middle Ordovician age unconformably overlie the Precambrian rocks in the southern part of the map area, and consist of red and green shales and lithographic limestone.

The metamorphic grade in the Precambrian rocks across the map area is upper amphibolite facies. This metamorphism is the result of the *circa* 1100 Ma metamorphic event characteristic of the Grenville Province. At least two earlier metamorphic events have probably affected in the Fishog subdomain. No evidence of granulite facies mineral assemblages was observed in granitoid rocks of the Fishog subdomain in the area.

The structural geology of the area is dominated by the three major tectonic zones which serve to separate the main rock groups in the map area (Figures 3, 4 and 5). Other structural elements of note are the fold structures in the western part of the Fishog subdomain which fold the older diorite, anorthosite and monzonitic rocks, but not the granite plutons. The central Fishog subdomain is cut by a north-trending fault set, which converges near Victoria Lake, and a later, northeast-trending set of faults which cut all units in the subdomain. Deformation in the granite plutons of the Fishog subdomain, which consists mainly of flattening and the development of a southeast-plunging lineation, increases towards the CMBBZ. Rocks near the CMBBZ, in the CMBBZ and in the Denna Lake and Glamorgan complexes all contain a shallow, southeast-plunging lineation. Structures within the map area are consistent with a model of northwest-directed thrusting of the CMB over the CGB (Davidson et al. 1984), although the similarity of lithologic types in the Denna Lake Structural Complex with those only 25 km to the southeast near Crystal Lake (Easton 1987a) indicates that thrusting may not have taken place over great distances.

A variety of mineral occurrences are present within the map area, some not previously recognized. Most metallic and nonmetallic mineral occurrences are located in the Denna Lake Structural Complex, and are associated with specific lithologic units within the complex. Dolomitic marbles near Buller Lake have potential for zinc, as well for tremolite or dolomite production. Graphite occurrences are also common along the edge of this block of dolomite marble at Buller Lake. Molybdenum may be present in the Miners Bay area, and in the southern part of the Denna Lake complex. Sulphide-rich schists in the Denna Lake complex should be investigated for economic potential. Radioactive mineral occurrences are restricted to the Denna Lake Structural Complex, and are associated with gamma ray spectrometric anomalies. The only mineral production in the area has come from two flagstone quarries in the CMBBZ, and the production of flagstone could be considerably expanded. Few mineral occurrences have been located in the Fishog subdomain, mainly due to the lack of exploration activity. Copper-nickel, gold and niobium-zirconium occurrences might be present within this subdomain. Sand and gravel deposits of good quality are located along the Gull River, and are another potential resource within the map area.

MIDDLE PROTEROZOIC

CENTRAL GNEISS BELT–FISHOG SUBDOMAIN (UNITS 1 TO 16)*

The Central Gneiss Belt of the Grenville Province underlies the western half of the map area, and includes the oldest rocks in the map area. Davidson et al. (1982, 1984) and Culshaw et al. (1983) have recognized a number of tectonic domains in the Central Gneiss Belt, each domain having characteristic lithologies and structures. The recognition of these zones has led to a better understanding of the development of the Central Gneiss Belt, and has assisted geologic mapping. Rocks within the map area, however, differ from rocks described within the typical Muskoka domain of Davidson et al. (1982, 1984) and Culshaw et al. (1983) which might be expected to underlie the map area. Schwerdtner and Mawer (1982) also noted that the area is distinct, is separated from what would be considered typical Muskoka domain rocks by the Kahshe Lake shear zone, and has a distinctive magnetic signature (*see section on* "Aeromagnetic Data"). For these reasons, the rocks in the area bounded by the CMBBZ to the east, the Kahshe Lake shear zone to the west and north, and the Paleozoic unconformity to the south have been informally termed the Fishog subdomain (Easton and Van Kranendonk 1984) in order to distinguish these rocks from the Muskoka domain. Further mapping is needed to the west and north to determine if the Fishog subdomain is part of the Muskoka domain, or whether it is a separate domain.

The Fishog subdomain is a predominantly meta-igneous terrane, underlain mainly by large monzonite and granite plutons. Rocks within the Fishog subdomain are similar to those described by Lumbers (1975, 1982) and Schwerdtner and Lumbers (1980) as constituting the Algonquin Batholith.

Older Gneisses (units 1, 2 and 3)

The oldest rocks in the map area consist of a series of dioritic, tonalitic, and calc-silicate gneisses exposed as slivers within, and adjacent to, the large monzonitic and granitic plutonic masses that underlie most of the Fishog subdomain (Figure 4). In addition, there is some lateral variation in the distribution of the older gneisses. Dioritic and tonalitic migmatitic gneisses (unit 1) are only exposed in a north-south band between Fishog Lake and the CMBBZ (Figure 4). Layered calc-silicate gneisses (unit 2) are only exposed in the Head Lake area (Figure 5), and dioritic and other mafic gneisses (unit 3) are only found west of the Fishog–Victoria lakes mylonite zone (Figure 5). Because of this areal variation in lithologic distribution, it is difficult to ascertain the age relations between these three rock units. The dioritic and tonalitic migmatitic gneisses are inferred to be the oldest unit, as they contain a leucosome not present in the other two units, perhaps indicating that unit 1 was subjected to an early metamorphic event that did not affect units 2 and 3. The age relations between units 2 and 3 are difficult to determine, and they could be roughly coeval. In places, the two units are interlayered, but this could indicate either a metasedimentary-metavolcanic origin for units 2 and 3; or a metasedimentary origin for unit 2, followed by intrusion of unit 3 as dikes or sills into unit 2.

DIORITIC TO TONALITIC MIGMATITIC GNEISSES (UNIT 1)

As mentioned above, this unit is only exposed in the Fishog subdomain between the Fishog–Victoria lakes mylonite zone and the CMBBZ (Figures 4 and 5). The largest areal exposure of this unit, relatively free of later intrusive phases, is located between Clear Lake and the northern boundary of the map area. Rocks of this unit are exposed elsewhere in this zone, but are present only as slivers and pods between the granitic sills and the granite plutons of unit 13 that underlie most of the region (Figure 4).

As discussed in the section "Aeromagnetic Data", the dioritic and tonalitic migmatitic rocks of unit 1, particularly the outcrop area between Clear Lake and the northern boundary of the map area, have a distinctive

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* *Lithologic unit numbers refer to those on Map 2530 (back pocket).*

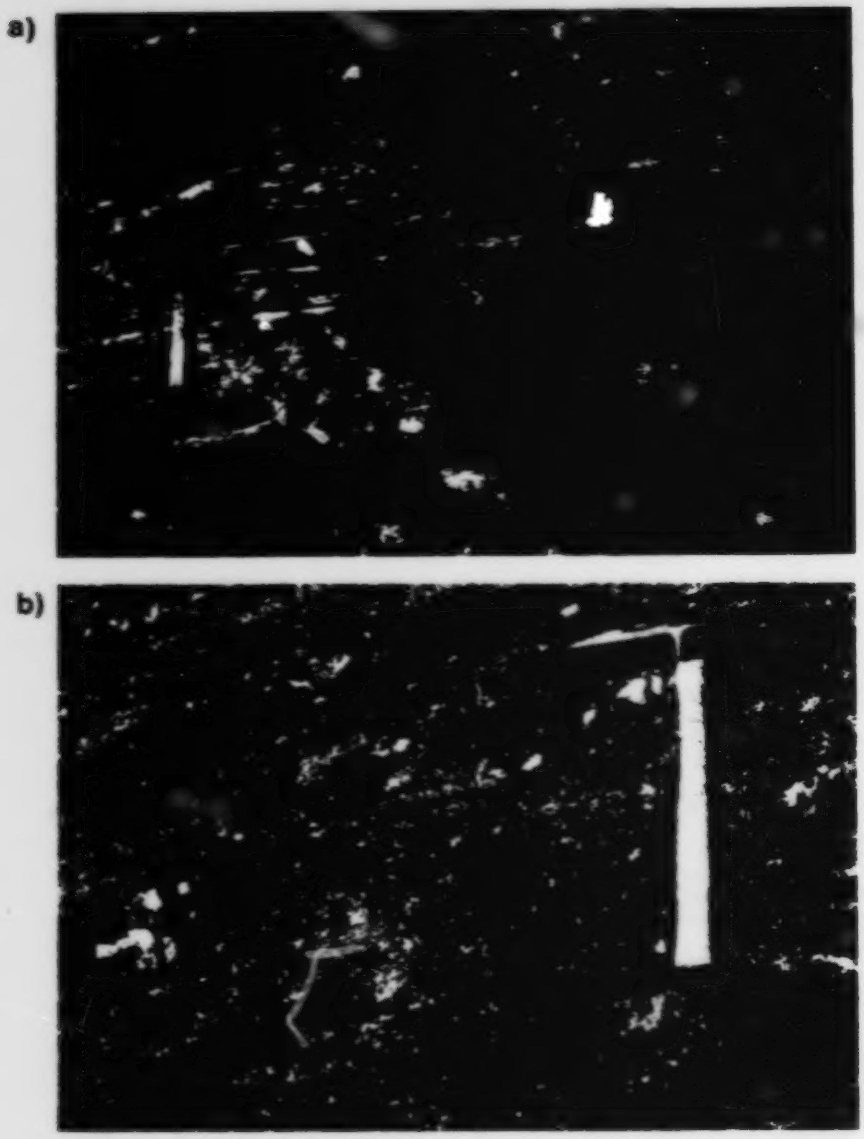


Photo 1. Tonalitic migmatitic gneiss of unit 1: a) leucosome-poor phase, b) leucosome-rich phase.

aeromagnetic signature. This is one of the few rock units in the map area to be magnetically distinctive.

Rocks of unit 1 vary from diorite to tonalite in composition. The colour index usually ranges from 20 to 40, which is high for these rocks to be classed as trondhjemites. In thin section, these rocks consist of a strongly recrystallized aggregate of biotite-hornblende-plagioclase (generally andesine) and quartz. Minor amounts of apatite and magnetite are also present. This unit is texturally distinctive, generally being fine to medium grained, with thin (5 to 15 mm thick), closely spaced (5 to 15 cm), discontinuous, leucosomal layers of granodioritic composition (Photo 1). As shown in Photos 1a and 1b, the proportion of the leucosomal phase varies from 5 to 50 percent of the rock. Compared to units 2 and 3, unit 1 is relatively homogeneous, showing only minor layering, and then only locally. The layering is commonly folded into small isoclines. Units 2 and 3, by way of contrast, show well-developed compositional layering, and in the case of unit 2, this layering may reflect original compositional differences in the rock. The overall homogeneity of unit 1 may indicate that it is a meta-igneous rock.

Units 1, 12 and 13 form a continuum of rock types ranging in composition from dioritic and tonalitic migmatitic gneisses to gneissic granite. Units 1 (intermediate to mafic gneisses) and 13 (gneissic granite) represent end members of two different ages in this continuum, with unit 12 representing a range of mixtures (25 to 75 percent unit 13 in unit 1) of the two end members. Although unit 12 is a distinct mappable entity (a true litho-

TABLE 4. CHEMICAL ANALYSES FROM UNIT 1, DIGBY–LUTTERWORTH AREA.

(wt. %)	1	2	3	4
SiO_2	69.30	48.70	69.10	65.60
TiO_2	0.59	1.45	0.51	0.61
Al_2O_3	14.20	13.00	14.80	15.50
Fe_2O_3	0.87	2.42	0.90	1.07
FeO	3.08	11.00	2.74	2.84
MgO	1.55	7.78	1.27	1.75
CaO	2.09	10.28	2.14	2.77
Na_2O	2.75	2.43	3.11	4.16
K_2O	4.02	0.97	3.66	3.27
P_2O_5	0.06	0.06	0.05	0.07
MnO	0.07	0.29	0.06	0.06
CO_2	0.13	0.10	0.12	0.29
S	0.02	0.02	0.11	0.17
H_2O^+	1.11	1.34	0.99	0.69
H_2O^-	0.05	0.06	0.09	0.01
total	99.89	99.82	99.65	98.86
(ppm)				
Co	10	45	< 5	12
Cr	141	181	160	33
Cu	30	34	60	47
Nb	8	8	7	8
Ni	15	65	5	12
Pb	32	< 10	26	23
Rb	105	< 5	90	135
Sr	220	85	220	910
Th	< 10	< 10	< 10	12
V	55	390	65	NR
Y	16	27	17	15
Zn	128	165	114	86
Zr	205	90	175	215

Notes
1: 84-RME-0324, migmatitic tonalite gneiss
2: 84-RME-0325, migmatitic tonalite gneiss
3: 84-RME-0326, migmatitic tonalite gneiss
4: 84-RME-0287, sheared migmatitic tonalite gneiss, adjacent to CMBBZ.
NR: not reported

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

demic unit although not formally named), it does incorporate rocks of two distinct ages. Thus, there is no ideal place for unit 12 in the map legend. Consequently, the author has chosen to discuss these mixed rocks under the section "Felsic Intrusive Rocks", as unit 12 is distinct from unit 1 because it contains varied amounts of unit 13, which is a younger intrusive phase.

Gneisses of unit 1 have been subjected to varying degrees of strain. In the leucosome-rich phases, the leucosome in particular (as well as the melanosome, but less distinctly) shows a protomylonitic texture (Higgins 1971). This texture is most commonly observed in these rocks within several hundred metres of the CMBBZ and the Fishog–Victoria lakes mylonite zone. Apart from alkali enrichment, there is not much difference in the bulk rock chemistry between the lower and higher strained rocks (compare analyses 3 and 4, Table 4).

Representative chemical analyses from the leucosome-poor phases of this unit are given in Table 4, analyses 1, 3 and 4.

LAYERED CALC-SILICATE AND RELATED GNEISSES (UNIT 2)

A series of unusual, poorly exposed, very thinly layered hornblende-biotite-plagioclase-quartz ("dioritic") gneisses, quartz arenites, quartzose felsites, and epidote- and scapolite-bearing dioritic gneisses are present within the domal structure centered on Head Lake (Figure 5), which is here informally termed the Head Lake oval. Many of these rocks contain 5 to 10 percent magnetite as an accessory mineral, but as discussed in the section "Aeromagnetic Data", they do not have an associated aeromagnetic high. In some of the quartz arenites and felsites, magnetite occurs as discrete, discontinuous bands, possibly reflecting original layering.

Rocks of unit 2 have proven difficult to interpret because they form poor outcrops and because they have been intruded by anorthosite and quartz diorite sheets (units 5 and 6, respectively) and by granite sills (unit 13). These intrusions cut layering in the calc-silicate and related gneisses, and locally the granites have partly assimilated the calc-silicate and related gneisses. Elsewhere, injection migmatites have formed, obscuring the original nature of the country rock. These relationships can be seen on a large scale west and southwest of Fishog Lake, where several sills of unit 13 intrude unit 2 (*see* Map 2530, back pocket).

The layered calc-silicate and felsite gneisses are interlayered with fine-grained, thinly to medium layered diorite gneisses (unit 3) that have an unknown protolith—the original contact relationship between units 2 and 3 is unknown.

Rocks on the northern shore of Head lake appear to have been subjected to more intense weathering than those in other parts of the map area. This weathering is probably associated with the nearby Paleozoic unconformity, which in southeastern Ontario is known to have paleoweathering features associated with it (DiPrisco and Springer, in preparation). Granites in this area have a deep red colour due to hematite staining, and granodiorite and monzogranite layers in the Head Lake oval are deeply weathered. Mafic minerals have been altered to chlorite, and feldspar has been altered to sericite and clay minerals. These weathering effects can also be seen in rocks of unit 2, and serve to obscure the original character of the rocks, particularly in thin section where only secondary alteration minerals are preserved.

A number of chemical analyses of rocks from unit 2 are listed in Table 5, analyses 1 to 6. In addition, analyses of other rock types from the Head Lake oval are listed in Table 5, as analyses 7 to 11. Analyses 1, 2 and 3, Table 5, are from gneisses clearly recognizable as having a metasedimentary parentage, for example, quartz arenites. Analyses 4, 5 and 6, Table 5, are from calc-silicate and other gneisses of unit 2 which have an indeterminate origin. Mafic gneisses of unit 3 that are associated with rocks of unit 2 are listed in Table 5 as analyses 7, 8 and 9. Intrusive granitic rocks of unit 13 are also shown in Table 5 (analyses 10, 11 and 12) for comparative purposes.

TABLE 5. CHEMICAL ANALYSES OF UNITS 2, 3 AND 13 FROM THE HEAD LAKE OVAL, DIGBY–LUTTERWORTH AREA.

	unit 2						unit 3			unit 13		
(wt. %)	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	61.10	69.70	72.90	59.40	52.70	65.60	65.60	57.50	49.70	63.80	75.30	73.90
TiO_2	0.42	0.33	0.37	1.26	2.02	0.83	0.33	2.14	1.04	0.90	0.28	0.30
Al_2O_3	21.60	15.20	13.10	14.00	15.90	11.20	18.30	13.90	16.80	16.00	11.80	13.60
Fe_2O_3	1.49	0.82	1.94	4.71	6.40	8.00	1.04	5.96	4.15	2.75	2.37	0.94
FeO	0.63	1.28	0.60	4.11	3.85	3.77	1.37	5.39	6.42	1.11	1.03	0.51
MgO	0.05	0.61	0.29	2.71	2.93	0.70	0.77	2.78	6.01	0.41	0.00	0.24
CaO	5.73	2.65	1.70	5.68	5.52	0.63	3.31	5.25	9.85	4.61	0.59	0.81
Na_2O	5.84	3.73	2.58	4.19	3.55	1.48	5.01	3.83	3.28	3.84	2.41	3.46
K_2O	1.21	3.01	4.42	1.51	4.09	6.02	2.42	1.62	1.12	3.48	4.93	4.91
P_2O_5	0.11	0.05	0.02	0.17	1.13	0.19	0.03	0.30	0.41	0.22	0.0	0.02
MnO	0.02	0.03	0.02	0.11	0.11	0.07	0.03	0.13	0.17	0.03	0.01	0.01
CO_2	0.30	0.60	0.43	0.57	0.26	0.10	0.11	0.08	0.20	1.55	0.12	0.13
S	0.01	0.10	0.0	0.08	0.18	0.01	0.01	0.02	0.21	0.01	0.01	0.0
H_2O^+	0.86	1.12	0.85	0.93	1.08	1.05	0.72	0.94	1.34	0.98	0.86	0.51
H_2O^-	0.0	0.0	0.5	0.07	0.08	0.05	0.0	0.0	0.08	0.06	0.0	0.03
total	99.42	99.23	99.27	99.50	99.80	99.70	99.05	99.84	100.78	99.75	99.71	99.37
(ppm)												
Co	<5	7	5	21	18	17	9	17	33	10	<5	<5
Cr	<10	<10	<10	32	<10	<10	<10	66	97	<10	<10	<10
Cu	6	40	<5	60	51	41	11	8	85	8	46	13
Nb	<5	6	5	19	28	22	<5	16	6	11	7	5
Pb	10	15	10	<10	49	<10	<10	<10	<10	23	<10	18
Rb	<5	65	49	11	49	170	41	11	<5	43	80	120
Sr	330	780	120	240	2150	90	400	145	570	260	24	170
Th	<10	<10	<10	<10	10	11	<10	<10	<10	<10	<10	<10
Y	8	12	<5	135	85	135	<5	145	11	23	60	20
Zn	16	45	11	88	170	56	35	64	122	18	18	28
Zr	155	190	150	350	520	605	125	295	80	380	490	160

Note:

1: 84-RME-1516, quartz arenite
2: 84-RME-1543, arkosic gneiss
3: 84-RME-1554, sublitharenite
4: 84-RME-1512, scapolite-bearing monzonitic gneiss
5: 84-RME-1551, calc-silicate gneiss
6: 84-RME-1547C, quartzose granitic gneiss
7: 84-RME-1519, granodiorite gneiss
8: 84-RME-1547B, diorite gneiss
9: 84-RME-1540, gabbroic gneiss (interlayered with unit 13)
10: 84-RME-1266, weathered granite gneiss (unit 13j)
11: 84-RME-1547A, gneissic granite
12: 84-RME-0097, red-weathering gneissic granite

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

The metasedimentary and other gneisses of unit 2 are only found in the Head Lake oval, and only near its core. This oval structure is the only such structure found in the map area, although similar structures are common in the Muskoka domain farther to the west (Schwerdtner and Mawer 1982). The oval is exposed in a topographic low of the area, and it is possible that the Head Lake oval is exposed as a window through sheets of overlying granitic sills and mafic gneisses. As discussed in the introduction to this section, contact relationships between units 1, 2 and 3 are unclear, this is in part related to the areal distribution of the rock units. Together, these three units constitute the oldest rocks in the Fishog subdomain, as they are all cut by younger rocks. In addition, it is not likely that the calc-silicate and other metasedimentary gneisses of unit 2 are in any way related to the Grenville supergroup rocks to the east, if the monzonitic and granitic rocks in the Fishog subdomain are similar in age to Muskoka area granitoids (i.e., 1400 to 1450 Ma, *see section on* "Geochronology".

DIORITIC GNEISSES AND OTHER MAFIC GNEISSES (UNIT 3)

Dioritic and other mafic gneisses (unit 3) are exposed in the western part of the Fishog subdomain, and occur as a band along the Head River north of Fishog Lake, as a band extending northwest to Crooked Lake from Fishog Lake, and in the Head Lake oval (*see* Map 2530, back pocket). These gneisses are interlayered with gneisses of unit 2 in the Head Lake oval, and form a component of the migmatitic gneisses (unit 4) located southeast of Smudge Lake which are related to the Smudge Lake monzonite pluton. As is the case with unit 2, gneisses of unit 3 are generally poorly exposed, most exposures being located on the lowermost flanks of granite ridges of unit 13. The mafic mineral component of these gneisses

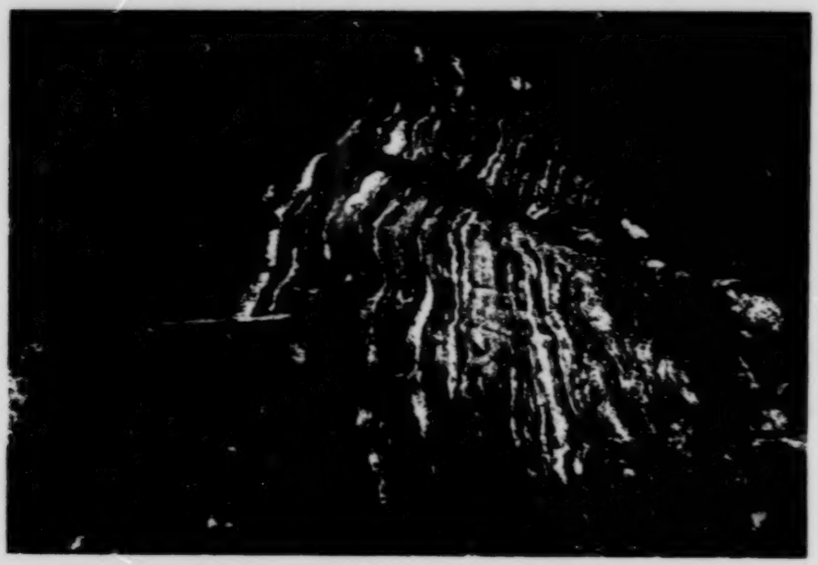


Photo 2. Migmatitic rocks deformed along the margin of a monzonite pluton south of Smudge Lake. The protolith of these rocks cannot be determined because of the degree of assimilation that has occurred. It is suspected that they may be derived from units 1, 2, or 3.

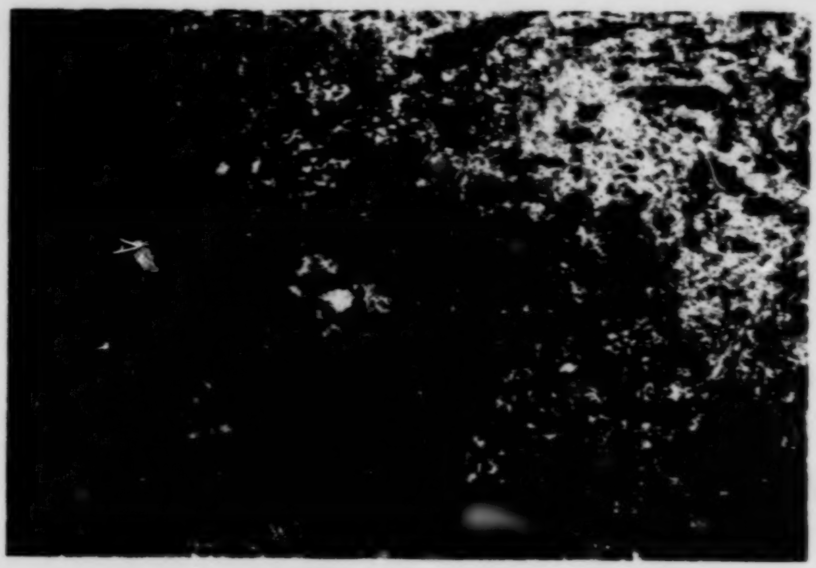


Photo 3. Hornblende aggregates in anorthosite of the Head River anorthosite sheet, Fishog subdomain. Photo from west-central limb of the sheet.

weathers more rapidly than the granitic rocks, contributing to the poor exposure of the mafic gneisses. The dioritic gneisses are commonly found as slivers and bands between the granite sills of unit 13, and are the remnant of what probably was, at one time, a more extensive dioritic terrane.

Most of the dioritic rocks are thinly to medium layered (Photos 2 and 3), in contrast to the more homogeneous gneisses of unit 1, and the quartz diorite, anorthositic gabbro and other mafic rocks of the anorthosite suite (units 6 and 7). The dioritic rocks consist mainly of biotite, hornblende and plagioclase, with varying amounts of quartz, and include rock types of diorite, gabbro, tonalite and quartz diorite compositions.

In thin section, these rocks consist of quartz-hornblende-biotite-plagioclase (mainly andesine) assemblages and have been thoroughly recrystallized. These rocks exhibit a strong fabric defined both by the elongation of plagioclase grains and the orientation of the micaceous minerals. The original nature of these rocks could not be determined either through field studies or by the examination of thin sections. The fact that these rocks are well layered, and show considerable compositional variability between layers, may indicate a metasedimentary or metavolcanic parentage.

Areas underlain by rocks of unit 3, or migmatitic rocks (such as unit 4) containing them, are those areas where major fold structures are observed in the Fishog subdomain. These structures include the Head Lake oval, the Head River syncline, and the folds in the Smudge Lake monzonite (Figure 5). No strain, or at least no strain that can be attributed to folding, is observed in the granite sills of unit 13, which have been injected parallel to the layering in these structures. In addition, no folds are observed in the granodiorite or granite plutons (units 11 and 13), which indicates that folding took place sometime after the formation of unit 3, but prior to the intrusion of units 11 and 13. It is not clear yet if the folds observed in the Smudge Lake monzonite pluton are due to folding after emplacement, or if the pluton was injected into the fold structure, and has assumed a folded form. The former is assumed more likely. In the Head River anorthosite, not all of the strain observed in the anorthosite is due to post-intrusion folding. This indicates that a period of deformation took place prior to the final folding of the intrusion, but after emplacement. It is not clear if this indicates that rocks of unit 3 were already folded at the time of anorthosite emplacement and the folds were tightened after anorthosite crystallization, or if all the folding took place after anorthosite emplacement. Nevertheless, folding occurred relatively early in the development of the Fishog subdomain, and is best preserved in rocks of unit 3.

The layering in the gneisses of unit 3 has served to influence the form of later intrusions. This is clear in the area north of Fishog Lake, where granodiorite intrusions (unit 11) form injection migmatites along their margins, with granodiorite being injected parallel to layering. As well, the form of the granodiorite intrusion is similar to the trend of the unit 3 gneisses. Similar situations exist where granite sills of unit 13 have been emplaced into gneisses of unit 3.

Migmatitic Rocks (unit 4; derived from units 2, 3, 10 and 13)

This unit consists of a variety of gneisses derived from the mixing of rocks of units 2 or 3 and 10 or 13 through the intrusion of magma accompanied by partial assimilation of the host rocks, anatexis and metasomatism. These gneisses occur mainly in the western part of the Fishog subdomain, and are exposed mainly along Fishog Lake and the Head River north of Fishog Lake, and surrounding the monzonite plutons centred in the vicinity of Smudge Lake. The degree of migmatization varies considerably; in places the two or three components of the rock are distinct, and can be easily recognized. Elsewhere, commonly along strike, migmatization has occurred to such an extent that the nature of the original components has been obscured, and the rock can only be described as a migmatite (Photo 2). Contacts between units 2 and 3 and unit 10 are gradational. Consequently, it is difficult to place distinct boundaries on the limits and the age of this unit. For this reason, these rocks are considered as unit 4, rather than as a younger unit. A number of varieties of migmatitic rocks have been distinguished in the map area, some of which are associated with specific intrusions. These varieties are briefly outlined below.

The first group consists of migmatitic gneisses associated with monzonite plutons of unit 10. Distinctions are made on the basis of leucosomal phase, proportion of country rock present and distinctive textures. These varieties include:

Unit 4a: heterogeneous, inclusion-rich monzonite gneiss of varied composition and layering, with 10 to 25 percent potassic pegmatite veins, grading into unit 10; assimilated material includes gneisses of unit 3, as well as calc-silicate blocks possibly derived from unit 2

Unit 4b: similar to 4a, but of blocky texture, and containing recognizable diorite, gabbro, and anorthositic gabbro blocks; only found near areas of anorthosite bodies

Unit 4c: fine- to medium-grained granite gneiss, containing 10 to 15 percent mafic to intermediate layers representing partly assimilated gneisses of units 2 and 3, grading into unit 10 or 13

Unit 4d: similar to 4c, but contains 15 to 25 percent mafic layers which are generally recognizable as dioritic gneisses of unit 3

Unit 4e: very heterogeneous rock consisting of unit 4c, but with an abundance of diorite, tonalite, granodiorite, and other blocks, layers and partly assimilated zones; may also be partly tectonic in origin, unlike the other units which are magmatic in origin

The second group consists of migmatitic rocks which may be derived from quartz diorite and other related gneisses of units 6 and 7. Unit 4f consists of migmatitic gneiss with a monzonite leucosomal phase constituting over 30 percent of the rock, and which may be derived from unit 6 or 7, or both. This unit grades into rocks of units 6 and 7 along strike. Unit 4g is a brecciated version of 4f containing blocks of gabbro, diorite and anorthosite. The migmatitic leucosome surrounds the blocks, and cuts them. This unit occurs as patches within 4f.

The third group is denoted as unit 4h, and consists of diorite slivers and layers within unit 13 showing partial assimilation, and which are located within and marginal to the large granite bodies of unit 13.

The fourth group is related to the anorthositic rocks of unit 5. Although somewhat different from the rest in lacking a large portion of granitic or monzonitic melt, these rocks are similar in origin to the other gneisses of unit 4. Three units are recognized in this group, but are probably gradational into each other. Unit 4n is a thinly layered heterogeneous diorite gneiss with 5 percent or less leucosome, which is present along strike with units

4k and 4m, and which can be recognized as being similar to some unit 3 gneisses. Along strike, this unit becomes more migmatitic, the proportion of leucosome of monzogranite composition increases from 5 to 15 percent, and the melanosome becomes less well layered (unit 4m) and does not resemble unit 3 as closely as in unit 4h. Further along strike, the leucosomal phase constitutes 30 to 40 percent of the rock, and begins to form an interlocking network of granitic veins (unit 4k). This unit is only located within 50 m of the southern margin of the Head River anorthosite sheet, and appears to represent partial melting in the country rock related to the emplacement of the anorthosite.

Anorthosite Suite Rocks (units 5, 6, 7 and 8)

The anorthosite suite of rocks in the map area consists of anorthosite and gabbroic anorthosite (unit 5) as well as mafic to intermediate, quartz-poor intrusive rocks (unit 6), gneissic quartz diorite (unit 7), and felsic intrusive rocks (unit 8) that are spatially and temporally associated with the anorthosites.

Rocks of the anorthosite suite outcrop in only four parts of the map area, these are:

1. in the Head Lake oval
2. in a folded anorthosite sheet north of Head River in the western Fishog subdomain
3. as a boudinaged sheet along the southern contact margin of the Smudge Lake monzonite pluton, located 1.5 km northwest of the Head River anorthosite sheet, and which extends north to Wolf Lake
4. a small body at the contact of the Denna Lake Structural Complex and the Glamorgan Gneiss Complex in the eastern part of the map area

This latter occurrence may not be genetically or temporally related to the anorthosites in the Fishog subdomain. This point is elaborated upon further in the text. Figure 6 shows the distribution of the anorthosite suite rocks in the map area and in the Minden region. Martin Van Kranendonk, a graduate student at the University of Toronto, studied the Head River anorthosite sheet as part of the requirements for a MSc thesis (Van Kranendonk 1987.

FISHOG SUBDOMAIN ANORTHOSITIC ROCKS

Head Lake Oval The anorthosite suite rocks in the Head Lake oval are poorly exposed due to the presence of Head Lake, low swampy topography, and weathering effects related to the adjacent Paleozoic/Precambrian unconformity. The best outcrops are found on the northern shore of Head Lake, and on two islands in the northern part of the lake. The islands are composed of anorthosite to anorthositic gabbro and gabbro. The anorthositic rocks are brecciated (20 cm to >2 m sized blocks) and are intruded by granitic pegmatite. The pegmatite makes up 5 to 25 percent of individual outcrops. The blocks have been rotated during brecciation and foliation and lineation trends are not consistent between blocks. This internal blocky texture is common in all three anorthosite sheets of the Fishog subdomain and has been previously described for thin anorthositic units of the Muskoka–Georgian Bay region (Van Kranendonk 1984, 1987). Exposures of anorthosite and anorthositic gabbro also occur on the northern shore of Head Lake. These rocks are similar to those on the islands in Head Lake, except for the presence of a unit of well-layered anorthosite and gabbro, consisting of 2 to 5 cm thick alternating layers of anorthosite and gabbroic anorthosite or gabbro. This layering is not gneissic, and is probably of igneous origin. It may indicate that differentiation occurred within the anorthosite sheet. The anorthosite outcrops on the mainland are only brecciated near their margins.

Anorthositic rocks in the Head Lake oval commonly display a lineated texture consisting of rods of stretched hornblende aggregates within a plagioclase groundmass. The anorthosites are equigranular and have been recrystallized. Average grain size is 3 to 5 mm. Lineation is more highly pronounced in the mafic members of the anorthositic rocks. A chemical analysis of an anorthosite from the Head Lake dome is presented in Table 6, analysis 6.

Also associated with the Head Lake oval anorthosite sheet are two other lenses of plagioclase-rich, quartz-poor intrusive rocks that may be related to the anorthosites. One lens that occurs halfway between Head and Fishog lakes is 1.5 km by 100 m in size, and consists of medium- to coarse-grained, homogeneous, gneissic diorite to quartz diorite (unit 6a). The second lens occurs 500 m west of Fishog Lake, and is about 1 km long by 150 m wide. It consists of medium- to coarse-grained, homogeneous gneissic quartz monzodiorite (unit 6b) which locally grades into quartz monzonite.

These anorthosite, quartz diorite and quartz monzodiorite lenses are intruded by a variety of monzonitic to granitic rocks (units 10 and 13). All the granitic rocks in the Head Lake dome are younger than the anorthosite suite rocks.

Head River Anorthosite Sheet The largest and best exposures of anorthosite and anorthosite suite rocks in the map area are located in the Head River synform. It is a 12 to 14 km long sheet of anorthosite that stretches from the Paleozoic cover south of Highway 503 to the Head River south of Smudge Lake. The nose of the folded anorthosite sheet is situated south of Smudge Lake. The limbs of the fold dip gently to the east at about 30°, and the hinge has an approximate trend of 110° and plunges at 80°. The synform is probably overturned.

Hornblende aggregates (*see* Photo 3) in the anorthosite and anorthositic gabbros of the sheet are lineated all along the limbs of the fold, and the intensity of the lineation increases towards the nose of the fold. This difference in intensity of the lineation between the limbs and the nose of the fold allows an estimate of the amount of stretching that was produced by folding. In addition, the lineation on the limbs of the fold indicates the degree of regional strain prior to folding and indi-

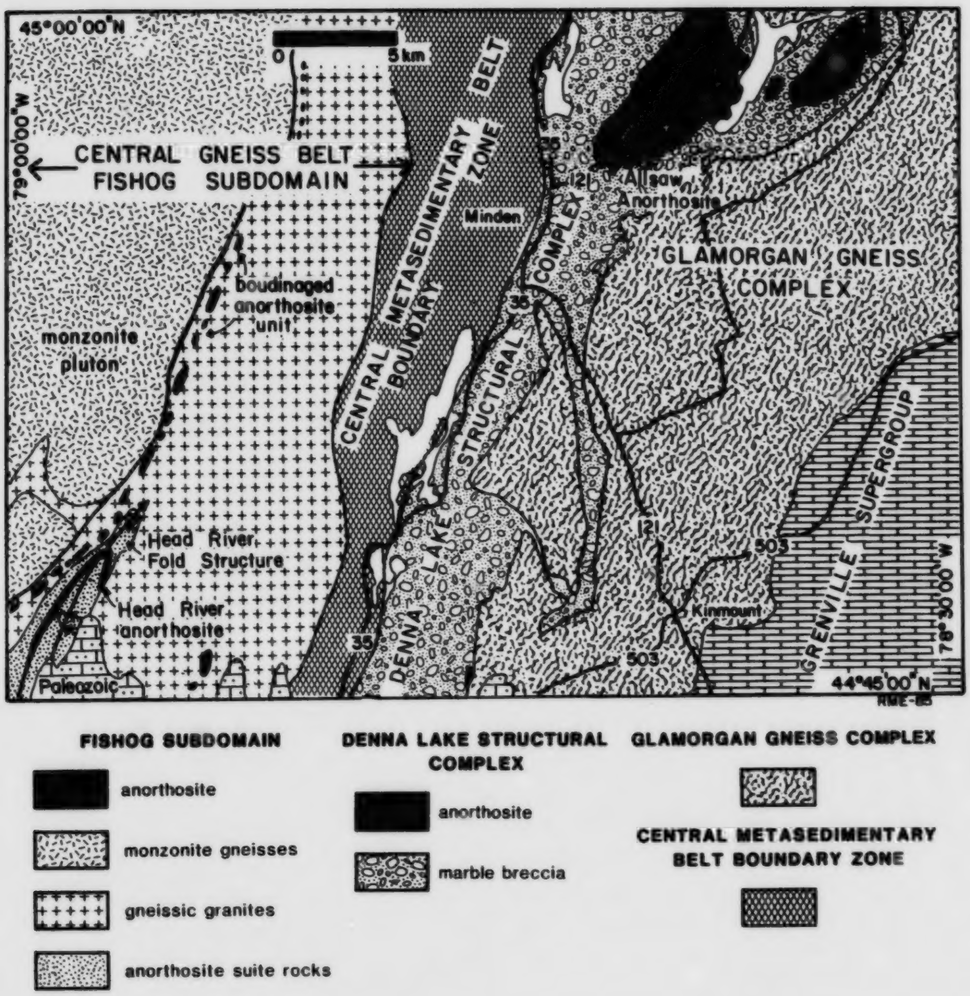

45°00'00"N
0
5 km
79°00'00"W
CENTRAL GNEISS BELT
FISHOG SUBDOMAIN
CENTRAL METASEDIMENTARY BOUNDARY ZONE BELT
Minden
DENNA LAKE STRUCTURAL COMPLEX
Allsaw Anorthosite
GLAMORGAN GNEISS COMPLEX
boudinaged anorthosite unit
monzonite pluton
Head River Fold Structure
Head River anorthosite
Paleozoic
35
121
503
Kinmount
GRENVILLE SUPERGROUP
78°30'00"W
44°45'00"N
RME-85
FISHOG SUBDOMAIN
anorthosite
monzonite gneisses
gneissic granites
anorthosite suite rocks
DENNA LAKE STRUCTURAL COMPLEX
anorthosite
marble breccia
GLAMORGAN GNEISS COMPLEX
CENTRAL METASEDIMENTARY BELT BOUNDARY ZONE

Figure 6. Distribution of anorthositic rocks in the Digby–Lutterworth and Minden areas.

cates that the anorthosite sheet was strained prior to folding.

Anorthositic rocks in the Head River anorthosite sheet are similar to those found in the Head Lake oval, and consist of medium- to coarse-grained anorthosite, commonly with well-developed hornblende aggregates (Photo 3) and medium- to coarse-grained anorthositic gabbro (Photo 4). Both rock types are equigranular and have been recrystallized. All mafic minerals are presently hornblende or chloritized hornblende, relict after pyroxene. Unlike the anorthosites in the Head Lake oval, much of the Head River anorthosite sheet is un-

TABLE 6. CHEMICAL ANALYSES OF ANORTHOSITE AND ANORTHOSITIC GABBRO (UNIT 5) FROM THE DIGBY-LUTTERWORTH AND MINDEN AREAS.

	Head River Sheet					Head Lake	DLSC	Highway 121, DLSC				Howland area diorites	
(wt. %)	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	48.2	55.2	49.5	50.1	54.10	51.20	49.90	48.0	49.8	50.9	51.1	52.3	54.5
TiO_2	0.48	0.37	1.02	0.28	0.92	0.18	0.65	0.03	0.12	0.09	0.10	0.15	0.19
Al_2O_3	25.7	23.0	22.5	27.1	15.60	28.60	19.30	26.4	27.0	29.3	29.6	19.5	17.3
Fe_2O_3	2.22	1.52	2.66	1.50	3.25	0.56	2.04	0.00	0.38	0.04	0.01	9.64	10.10
FeO	2.91	2.18	3.93	1.75	5.67	0.94	4.71	0.65	0.95	0.58	0.44	NR	NR
MgO	2.28	1.86	3.04	1.48	5.14	0.76	5.25	0.39	1.75	0.32	0.19	0.16	0.18
CaO	12.4	8.98	10.6	11.8	8.73	10.80	12.20	13.8	13.7	12.6	12.69	4.19	3.78
Na_2O	3.42	4.87	3.62	3.68	3.42	3.97	3.36	5.37	4.23	4.43	4.45	8.62	5.18
K_2O	0.66	0.93	1.27	0.84	1.05	1.24	0.82	0.82	0.36	0.48	0.38	1.43	5.84
P_2O_5	0.13	0.12	0.27	0.12	0.12	0.03	0.03	0.07	0.00	0.01	0.01	0.07	0.05
MnO	0.08	0.08	0.11	0.05	0.16	0.02	0.12	0.03	0.02	0.01	0.01	0.22	0.14
CO_2	0.42	0.27	0.26	0.25	0.07	0.09	0.31	2.37	0.99	0.63	0.58	2.14	2.14
S	0.01	0.01	0.12	0.02	0.01	0.01	0.06	0.50	0.08	0.08	0.08	0.09	0.0
H_2O^+	0.31	0.38	0.65	0.58	0.92	1.11	1.10	0.23	0.17	0.29	0.22	0.0	0.0
H_2O^-	0.05	0.06	0.11	0.11	0.04	0.07	0.0	0.07	0.07	0.01	0.02	0.0	0.0
total	99.2	99.8	99.6	99.7	99.20	99.58	99.85	98.7	99.6	99.7	99.8	98.51	99.40
(ppm)													
Ba	210	370	720	250	NR	NR	NR	560	150	420	510	NR	NR
Co	15	11	20	12	31	9	26	6	10	6	5	NR	NR
Cr	11	18	34	9	154	13	93	--	34	6	--	NR	NR
Cu	8	68	96	15	74	8	12	7	10	8	6	NR	NR
Li	13	10	14	17	NR	NR	NR	26	13	14	12	NR	NR
Mo	< 3	< 3	< 3	< 3	< 3	< 3	< 3	--	--	--	--	--	--
Nb	17	9	13	7	8	< 5	6	4	4	4	3	11	12
Ni	9	11	22	8	30	22	44	--	12	--	--	NR	NR
Pb	16	15	< 10	11	< 10	13	10	52	--	12	23	NR	NR
Rb	10	< 10	< 10	20	8	5	5	12	--	--	--	40	120
Sc	10	9	13	5	NR	NR	NR	--	4	--	--	1	--
Sr	455	1295	1490	1400	320	490	545	765	580	1000	1180	230	260
Th	7	5	< 10	< 10	< 10	< 10	< 10	--	--	--	--	--	--
V	155	95	155	90	NR	16	155	5	40	11	5	6	4
Y	8	16	23	5	20	< 5	16	6	2	2	2	85	30
Zn	46	50	78	38	100	22	90	28	24	30	22	NR	NR
Zr	25	25	50	13	115	60	90	--	--	--	--	75	30

1: 84-RME-0082, anorthositic gabbro, Highway 503, Head River sheet, Fishog Subdomain
2: 84-RME-1772, anorthosite, Head River sheet, Fishog Subdomain
3: 84-RME-1847, anorthosite, Head River sheet, Fishog Subdomain
4: 84-RME-1854, anorthosite, Head River sheet, Fishog Subdomain
5: 84-RME-1902, weathered gabbroic anorthosite, Head River sheet, Fishog Subdomain
6: 84-RME-1277, anorthosite, Head Lake oval, mainland, Fishog Subdomain
7: 84-RME-1435, anorthositic gabbro, Denna Lake Structural Complex, Digby area
NR: not reported
--: not detected

8: 84-RME-334, scapolitized anorthosite, Highway 121, Denna Lake Structural Complex, Lochlin area
9: 84-RME-335, anorthosite, Highway 121, Denna Lake Structural Complex, Lochlin area
10: 84-RME-381, anorthosite, Denna Lake Structural Complex, Lochlin area
11: 84-RME-382, anorthosite, Denna Lake Structural Complex, Lochlin area
12: 83-RME-165, leucodiorite, magnetite (about 10% of rock), nepheline-bearing, Howland area, Gooderham Syenite Belt
13: 83-RME-525, magnetite diorite, Howland area, Gooderham Syenite Belt

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

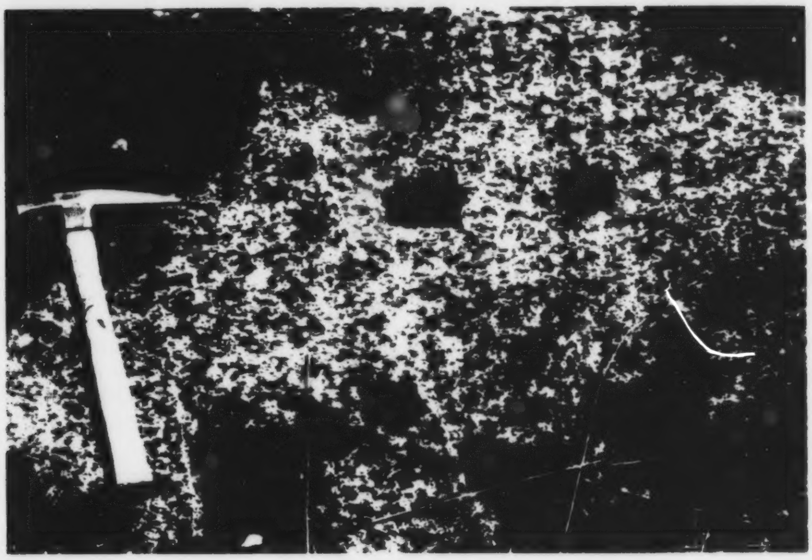


Photo 4. Anorthositic gabbro, Head River anorthosite sheet, Fishog subdomain, Highway 503 west.

brecciated, homogeneous and continuous. Only locally does the sheet show a brecciated, pegmatite-annealed texture, and then only near its margins. Chemical analyses of anorthositic rocks from the Head River anorthosite sheet are presented in Table 6, analyses 1 to 5.

Spatially associated with the anorthositic rocks in the Head River synform are a number of quartz-poor intrusive rocks. These are found nowhere else in the map area and include the following rock types.

Unit 6: homogeneous, medium- to coarse-grained gneissic quartz diorite to quartz monzodiorite which occurs in the nose of the Head River synform; on the limbs of the synform, these units are intruded by granitic rocks and grade into the migmatitic gneisses of unit 4 (units 4n, 4f) when the nature of the mafic component becomes obscure

Unit 6d: a homogeneous, medium- to coarse-grained quartz monzonite dike intrudes rocks of unit 4 near the nose of the Head River synform

Unit 7: a homogeneous body of medium-grained, gneissic quartz diorite occurs northeast of the Head River synform

Unit 8: fine-grained granite gneiss with abundant mafic and gabbroic inclusions which occurs along the northwestern flank of the anorthosite sheet

Units 13m and 13p: granite with potassium feldspar megacrysts up to 4 cm long (13m) and a leucocratic granite gneiss, locally aplitic (13p), which follow the form of the fold, and are probably folded as well

Units 4k, 4m and 4n: dioritic migmatite located along the southeastern margin of the anorthosite sheet; may have formed by partial melting of the country rocks as the anorthosite was emplaced

The results of chemical analysis of most of these units are presented in Table 7. On the basis of this limited number of analyses, it is not possible at this time to either prove or disprove a genetic relationship between the anorthositic rocks and the other rocks tentatively assigned to the anorthosite suite.

Based on observations made during the course of the present geological survey, a tentative generalized geologic history for the Head River synform and anorthosite sheet has been determined, and is presented below. This geologic history is important not only to the understanding of how this particular structure developed, but also of how it relates to the history of the western Fishog subdomain in the map area.

1. Anorthositic rocks (unit 5) were intruded into an older, probably gneissic terrane (now units 2 and 3) about 1450 Ma (*see section on* "Geochronology"). The country rocks were probably well layered, as the anorthosite was intruded as a sill-like body. The intrusion was probably layered, and differentiated with time to produce the anorthosite suite rocks associated with it. Melting occurred on the (lower?) (now southeast) margin of the anorthosite intrusion, producing a dioritic migmatite (now units 4k, 4m and 4n).
2. Metamorphism and regional deformation occurred sometime later. The anorthositic rocks were recrystallized during this metamorphic event to produce the plagioclase and hornblende aggregates that form lineated rods in the anorthosite on the limb of the Head River synform.
3. The intrusion of the potassium feldspar megacrystic granite sill occurred after the formation of the mineral aggregates, but prior to folding and the peak of deformation.

TABLE 7. CHEMICAL ANALYSES OF ANORTHOSITE SUITE ROCKS (UNITS 6, 7, AND 8) FROM THE DIGBY-LUTTERWORTH AREA.

(wt. %)	1	2	3	4	5	6	7
SiO_2	53.3	51.4	58.2	55.8	64.6	49.5	54.80
TiO_2	0.67	0.97	0.96	0.34	0.51	1.02	0.47
Al_2O_3	17.6	17.7	19.6	22.9	16.9	22.5	22.30
Fe_2O_3	2.21	3.50	2.47	1.83	1.37	2.66	1.80
FeO	4.29	4.95	2.62	1.75	1.82	3.93	2.55
MgO	5.20	5.61	1.82	1.90	1.79	3.04	1.93
CaO	9.58	8.93	5.02	7.37	2.66	10.6	8.72
Na_2O	4.18	3.77	5.20	5.51	4.11	3.62	4.76
K_2O	0.95	1.23	1.87	1.16	4.22	1.27	1.01
P_2O_5	0.16	0.24	0.23	0.14	0.19	0.27	0.09
MnO	0.13	0.13	0.11	0.07	0.04	0.11	0.09
CO_2	0.38	0.15	0.12	0.08	0.49	0.26	0.35
S	0.02	0.06	0.07	0.01	0.01	0.12	0.01
H_2O^+	0.73	0.89	0.50	0.48	0.62	0.65	0.56
H_2O^-	0.07	0.14	0.11	0.17	0.14	0.11	0.06
total	99.50	99.80	98.90	99.50	99.50	99.60	99.50
ppm							
Co	24	30	9	13	13	20	12
Cr	93	97	8	18	24	34	28
Cu	22	62	26	6	23	96	14
Nb	12	13	12	9	10	13	6
Pb	< 10	< 10	< 10	11	14	< 10	< 10
Rb	< 5	11	38	< 5	90	20	< 5
Sr	530	560	765	1820	1320	1490	1190
Th	< 5	< 5	< 5	< 5	12	< 5	< 10
Y	21	18	40	12	17	23	18
Zn	82	89	70	46	52	78	59
Zr	22	35	120	35	205	50	130

Notes:
1: 84-RME-1584, monzodiorite (unit 6b)
2: 84-RME-1587, monzodiorite (unit 4n)
3: 84-RME-1784, quartz diorite to quartz monzodiorite (unit 7)
4: 84-RME-1838, monzodiorite (unit 6)
5: 84-RME-1846, megacrystic granite (unit 13n)
6: 84-RME-1847, mafic anorthositic gneiss (unit 5a)
7: 84-RME-1843, diorite (unit 4k), matrix
Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

4. Regional folding or refolding, or both, of the anorthosite occurred, leading to the development of the Head River synform and the strong lineation observed in the nose of the anorthosite sheet. Also at about this time, the monzonite plutons (now unit 10) were emplaced. Folding may have been in part related to the emplacement of these plutons. At this time, the anorthosite sheet south of Smudge Lake was boudinaged, and the sheet brecciated and injected by granitic and monzonitic magmas. Intrusion of the monzonites probably occurred about 1400 Ma (*see section on* "Geochronology"). Events 2, 3 and 4 were probably closely spaced in time.
5. A quartz diorite pluton (unit 7) was intruded into the nose of the Head River fold. Quartz diorite (unit 6d) was also emplaced as a dike at this time. Again, this event may have been roughly contemporaneous with folding and the emplacement of the monzonitic rocks.
6. Syenogranite gneiss (now unit 13) was emplaced into the core of the fold. Again, this event may have been roughly coeval with the last few magmatic events. Magmatic activity probably ceased at about 1400 Ma.

Subsequent events include a possible metamorphic event at *circa* 1250 Ma, as well as a regional metamorphic event related to the main Grenville (Ottawan) orogeny at about 1100 Ma (*see section on* "Geochronology"). These later events do not seem to have had a profound effect on the Head River anorthosite sheet or synform.

This geologic history is significant in that it indicates that much of the deformation and magmatic activity associated with the Head River synform occurred well before the main Grenville (Ottawan) Orogeny. In addition, magmatism and deformation may have been closely related in time, and relatively short-lived. Further geochronologic work in the region would assist in verifying the history outlined above.

Boudinaged Anorthosite Sheet This sheet extends from the west-central part of the map area to Wolf Lake and beyond. At its southern extent, it lies about 1.5 km north of the Head River anorthosite sheet. It consists of several *en échelon* lenses of brecciated anorthositic gabbro and gabbroic anorthosite, with some anorthosite blocks in a monzonitic to granitic pegmatitic matrix. Material in the matrix is similar to some of the pegmatitic dikes associated with the monzonite plutons of unit 10, as well as the leucosomal material present in the migmatitic gneisses of unit 4. The lenses are elongated in the direction of the regional foliation, which in this part of the area is northeast to north-northeast. The lenses occur in a heterogeneous, migmatitic gneiss (unit 4) that is a marginal phase of the Smudge Lake monzonite plutons. These lenses are not related to any mylonite or high strain zone currently present in the area. The lenses appear to be related to disruption of a thin, linear anorthosite sheet during emplacement of the monzonite plutons. The lens-like shape of the sheet has been enhanced by large-scale boudinage of the anorthosite sheet, probably related to emplacement of the monzonite.

EASTERN ANORTHOSITIC ROCKS

A small body of anorthosite is present at the margin of the Denna Lake Structural Complex and the Glamorgan Gneiss Complex in the southeast corner of the map area (Figure 6). This body is composed of anorthosite and anorthositic gabbro, and is mineralogically and texturally similar to the Head River anorthosites. This is a relatively homogeneous body, and is not brecciated. The results of a chemical analysis from this body is presented in Table 6, analysis 7. It is similar to results obtained from samples of anorthosites in the Denna Lake Structural Complex, from Highway 121 northeast of the map area (Figure 6) in having low FeO, P_2O_5, V, Zr, Y and TiO_2 contents (Table 6, analyses 8, 9, 10, 11; Figure 7), as well as extremely low normative apatite versus ilmenite and magnetite ratios. These rocks are also nepheline normative (4 to 14 percent) unlike the Fishog subdomain anorthosites which are neither quartz nor nepheline normative. The eastern anorthosites (those located in the Denna Lake Structural Complex, Figure 6) are chemically distinct from the Fishog subdomain anorthosites, and they may be genetically more closely related to monzodiorites and other plagioclase-rich, nepheline-normative and nepheline-bearing leucodiorite rocks of the Gooderham Syenite Belt, which are present in the

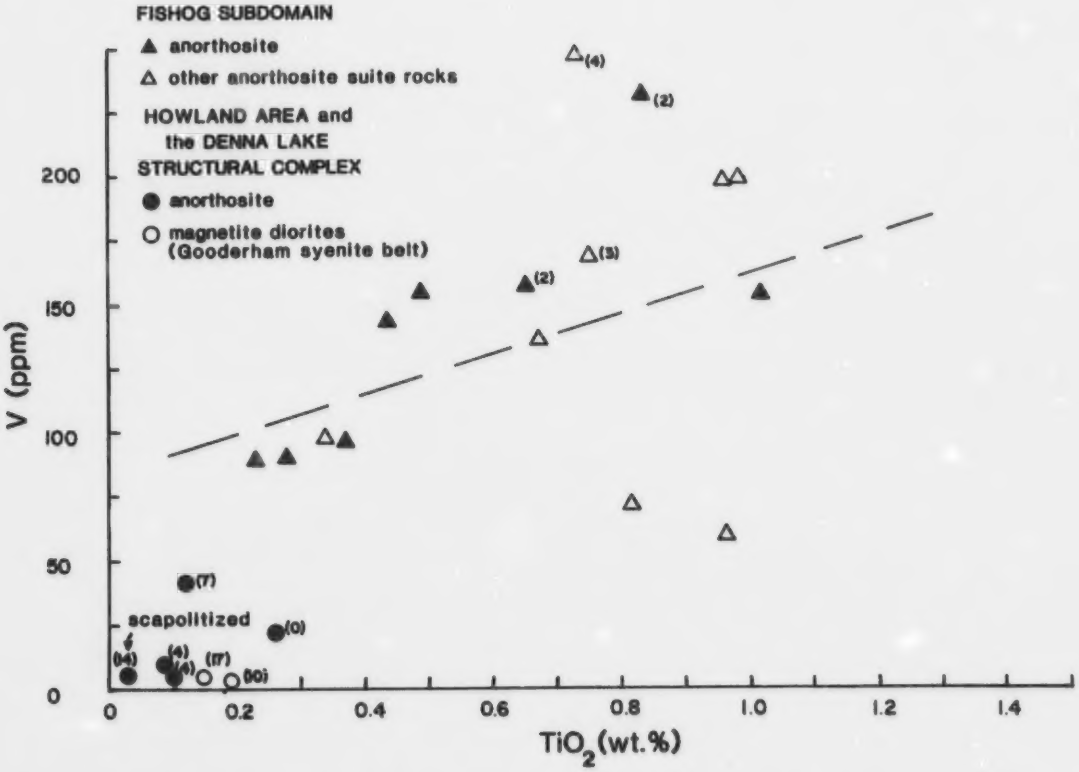


Figure 7. V versus TiO_2 plot for anorthosite suite rocks, Digby–Lutterworth and Minden areas. Note that nepheline-bearing and nepheline-normative plagioclase-rich rocks of the magnetite diorite suite (Gooderham syenite belt) in the Howland area also have low Ti and V values, similar to the anorthosites in the eastern part of the map area and elsewhere in the Denna Lake Structural Complex. This is noteworthy, since some of the magnetite diorite rocks contain 10 to 15 percent magnetite, yet have very low TiO_2 and V contents. The Fishog subdomain anorthosites have higher V and TiO_2 contents and are neither quartz nor nepheline normative. A plot of Zr, P_2O_5, Y or Nb versus TiO_2 would show a similar pattern. Bracketed numbers refer to percent nepheline in CIPW norm of sample.

Howland area along the southeastern side of the Glamorgan Gneiss Complex (Figure 6). If this is the case, then these rocks are significantly younger (*circa* 1280 Ma, Easton 1986) than the anorthosites in the Fishog subdomain (*circa* 1450 Ma, *see section on* "Geochronology").

Subsequent rare earth element analyses on samples of anorthosite from the Denna Lake Structural Complex (Easton 1987b, in press) have rare earth element patterns identical to rocks from the Gooderham Syenite Belt. Both are geochemically distinct from samples of anorthosite from the Fishog subdomain and the Central Gneiss Belt.

TECTONIC CONSIDERATIONS

The Fishog subdomain anorthosites differ in some aspects from anorthositic rocks of the Muskoka–Georgian Bay region. Gabbro and ultramafic rocks are generally not found in association with the Fishog subdomain anorthosites, whereas they are common in the Muskoka–Georgian Bay area (Van Kranendonk 1984, 1987). The Fishog subdomain anorthosites are generally not gneissic, but this may reflect lower regional strain undergone within the Fishog subdomain relative to the Muskoka–Georgian Bay area. Most significantly, the Fishog subdomain anorthosites are not found adjacent to major tectonic structures such as high strain zones, gneissic tectonites or mylonite zones. Such features are commonly adjacent to anorthositic rocks in the Muskoka–Georgian Bay region (Davidson et al. 1982). The Fishog subdomain rocks may be similar to the Muskoka–Georgian Bay anorthosite sheets, but may have been subjected to a lesser degree of strain and have not undergone tectonic disruption and disaggregation.

Monzonite Suite Intrusive Rocks (units 9 and 10)

This suite of rock outcrops as two large plutonic masses in the western Fishog subdomain; one located southwest of Smudge Lake, and the other located northwest of Smudge Lake and extending north to Logan Lake and east to Wolf Lake. Unlike the younger felsic intrusions of the Fishog subdomain, the monzonite suite plutons appear to be folded, based on the distribution of the surrounding country rocks, the trace of inclusion-rich zones and phases within the plutons and the orientation of gneissosity within the plutons. Aeromagnetic contours over the pluton also show evidence of folding (*see section on* "Aeromagnetic Data"; *see also* Geological Survey of Canada 1952).

Also, unlike the younger plutons, the monzonite suite plutons have broad, indistinct contact margins which are full of inclusions of country rock, commonly partly assimilated, and which grade into the migmatitic rocks of unit 4. Even the cores of the monzonite plutons are full of inclusions, and show a great deal of compositional and textural heterogeneity. There are two subdivisions within the monzonite suite of plutons. A somewhat older series of monzodiorite, granodiorite and monzonite gneiss (unit 9) occurs northwest of Smudge Lake and is cut by the slightly younger monzonites of unit 10. The rocks of unit 9 may be a marginal phase, or an early intrusive phase of the monzonite suite, and are not regarded as a separate plutonic event.

The bulk of the monzonite plutons consist of a medium-grained, only locally coarse-grained, gneissic monzonite (unit 10). Composition on any one outcrop may range from granodiorite to monzonite, feldspar being the main mineralogic variable, with mafic mineral content being relatively constant. Parts of the monzonite complex are cut by monzogranite veins which have ill-defined margins, are only present in the monzonite plutons and are mineralogically similar to the monzonites. Consequently, these dikes and veins appear to be related to the monzonite plutons and not the late granite pegmatites of unit 32.

Mafic minerals in the monzonites make up from 5 to 15 percent of the rock, and consist of biotite and hornblende, with biotite being more abundant. Thin section examination reveals that the rocks have been recrystallized, and that no relict igneous textures are apparent. No evidence of pyroxene was observed in any of these rocks and the plutons are probably at upper amphibolite facies. The results of chemical analyses of the monzonites are presented in Table 8, analyses 1 to 5, and are similar to the results from other monzonite plutons from the Grenville Structural Province Central Gneiss Belt (e.g., Table 8, analysis 6; Lumbers 1975).

Intermediate Intrusive Rocks (unit 11)

Plutons of gneissic granodiorite occur in the area of the Fishog subdomain. A subcircular pluton intrudes migmatitic rocks of unit 1 between Red Boat and Clear lakes. A lenticular, north-trending pluton extends from the southeastern shore of Fishog Lake to north of Victoria Lake. This pluton can be seen to clearly intrude gneisses of unit 3 along its western margin, and has formed injection migmatites along its margin consisting of granodiorite sills intruded into unit 3 along gneissosity. A second, lenticular, gneissic granodiorite pluton also occurs west of Fishog Lake, and this pluton links with the other Fishog pluton north of Crooked Lake. The western pluton is sheared along its western margin and the granodiorite pluton north of Crooked Lake is also extensively sheared along its western margin. This shearing is associated with the thin band of older gneisses that occurs between the monzonite plutons of Smudge Lake and the gneissic granodiorite and granite plutons of the Head River, and may in part be related to emplacement of the plutons. This band of well-layered older rocks is also most likely the site of later movement, rather than the more massive, homogeneous monzonite and granitic plutons.

The gneissic granodiorite plutons are medium- to coarse-grained, and consist mainly of biotite, quartz, plagioclase (oligoclase and andesine) and potassium feldspar. Some hornblende is locally present, but is commonly corroded and altered to form biotite. Locally, relict potassium feldspar phenocrysts are observed in thin section, despite the fact that the rocks have been

TABLE 8. CHEMICAL ANALYSES OF INTRUSIVE PLUTONIC ROCKS IN THE DIGBY-LUTTERWORTH AREA (UNITS 9 THROUGH 14).

(wt. %)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
SiO_2	61.80	70.30	68.60	61.60	59.40	64.4	64.1	64.40	62.5	77.00	75.50	75.50	73.90	66.40	64.6
TiO_2	0.49	0.51	0.65	0.67	0.85	0.73	0.44	0.31	0.45	0.24	0.14	0.24	0.30	0.56	0.51
Al_2O_3	16.80	14.70	13.90	19.60	18.10	16.0	18.3	19.10	18.8	11.90	12.00	12.10	13.60	15.50	16.9
Fe_2O_3	1.97	1.51	1.21	1.69	2.50	1.16	1.36	1.08	1.82	1.45	1.14	1.87	0.94	2.16	1.37
FeO	2.91	1.20	1.80	1.71	3.00	4.77	1.75	1.24	1.89	0.87	0.44	0.65	0.51	2.11	1.82
MgO	1.88	0.51	0.90	0.91	1.90	0.76	1.45	0.90	1.54	0.10	0.13	0.10	0.24	1.04	1.79
CaO	4.48	1.53	1.32	5.21	4.84	2.63	4.13	3.88	4.73	0.42	0.23	0.36	0.81	3.30	2.66
Na_2O	4.73	2.84	3.15	5.53	4.66	3.79	5.40	6.20	5.62	3.12	3.52	3.61	3.46	3.23	4.11
K_2O	2.00	5.43	5.04	1.45	2.64	4.60	1.70	1.51	1.41	4.58	4.60	4.40	4.91	3.09	4.23
P_2O_5	0.12	0.04	0.11	0.18	0.27	0.22	0.05	0.06	0.12	0.0	0.0	0.02	0.02	0.08	0.19
MnO	0.09	0.04	0.04	0.05	0.09	0.12	0.04	0.03	0.06	0.03	0.01	0.01	0.01	0.05	0.04
CO_2	0.05	0.05	0.18	0.16	0.10	0.32	0.15	0.19	0.09	0.09	0.09	0.11	0.13	0.06	0.49
S	0.01	0.0	0.01	0.0	0.01	0.0	0.01	0.01	0.01	0.0	0.0	0.0	0.0	0.01	0.01
H_2O^+	0.92	0.92	1.24	0.94	0.90	0.40	0.35	0.35	0.47	0.27	0.26	0.34	0.51	0.57	0.62
H_2O^-	0.0	0.0	0.0	0.0	0.0	0.26	0.18	0.03	0.06	0.01	0.02	0.04	0.03	0.01	0.14
total	98.25	99.58	98.15	99.70	99.26	100.00	99.40	99.29	99.60	100.08	98.08	99.35	99.37	98.17	99.50
(ppm)															
Rb	30	125	75	15	70	NR	30	19	10	75	75	70	120	95	90
Sr	465	405	190	410	565	NR	655	430	550	60	37	55	170	445	1320
Zn	82	48	50	66	106	NR	36	33	52	33	17	29	28	50	52
Zr	110	305	485	185	270	NR	10	150	5	295	110	580	160	360	205

Notes:

1: 84-RME-1658, monzonite, Smudge Lake pluton
2: 84-RME-1752, " " " "
3: 84-RME-1887, " " " "
4: 84-RME-1890, " " " "
5: 84-RME-1891, " " " "
6: #16, average of 6 monzonites, Lumbers (1975)
7: 84-RME-1490, granodiorite, Fishog pluton
8: 84-RME-1722, granodiorite, Clear Lake pluton
9: 84-RME-0254, monzogranite, marginal to Fishog granodiorite
10: 84-RME-0307A, granite
11: 84-RME-0307B, granite
12: 84-RME-0307C, granite
13: 84-RME-0097, granite, Head Lake oval
14: 84-RME-1840, granite, Head River synform
15: 84-RME-1846, granite, Head River synform
NR: not reported.

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

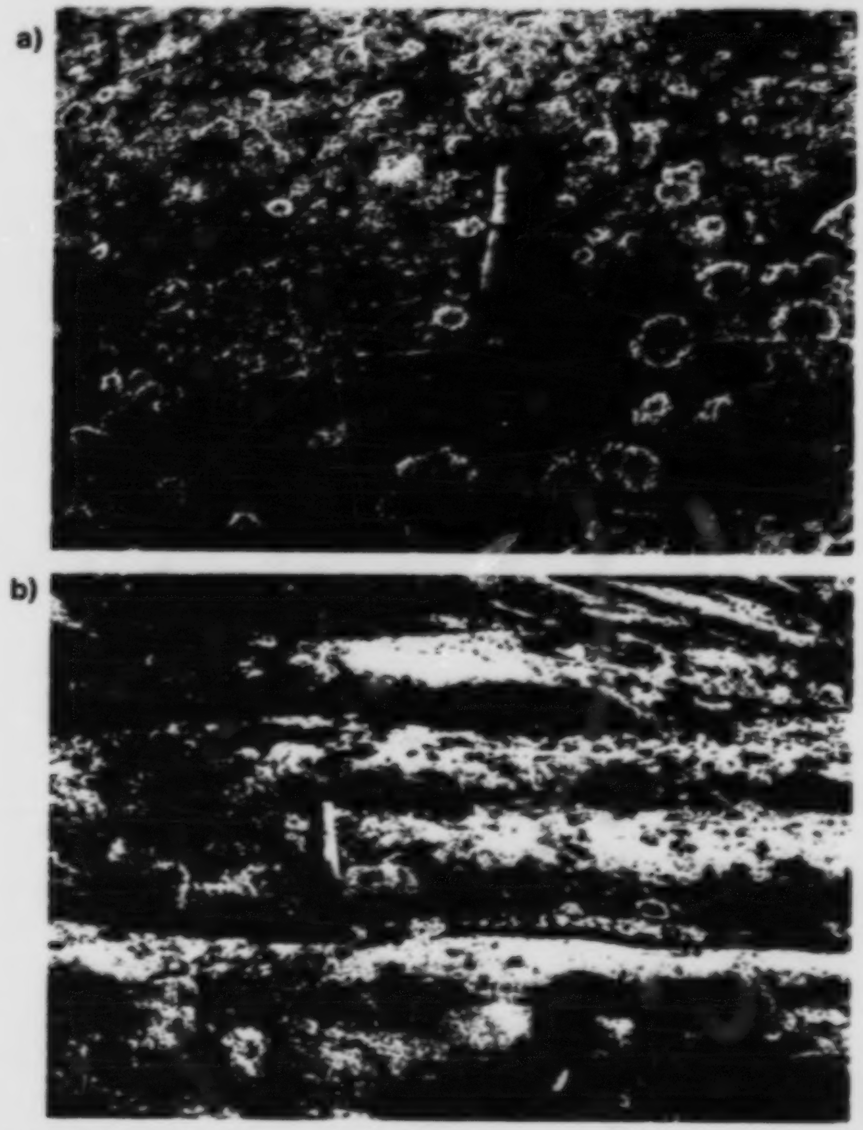


Photo 5. a) Massive, gneissic granite intrusion (unit 13) of the Fishog subdomain; b) layered gneissic granite (unit 14) of the Fishog subdomain. Note discontinuous mafic layers.

recrystallized. A weak fabric is observed in thin section, which arises from orientation of biotite and feldspar grains. The gneissic granodiorite plutons are relatively homogeneous, and in the case of the two westerly bodies, are sill-like in form. The form of the intrusions may be structurally controlled. The sill-like bodies occur in the well-layered gneisses of unit 3 and 4. The more circular body occurs in the more homogeneous gneisses of unit 1.

The results of chemical analysis of gneissic granodiorites are presented in Table 8, analyses 7 and 8.

Felsic Intrusive Rocks (units 12, 13 and 14)

Three subdivisions occur within this plutonic suite. The main rock type consists of massive gneissic granites of unit 13 (Photo 5). The other two units are migmatitic gneisses derived from unit 13 and the country rocks to unit 13.

Unit 12 consists of migmatitic gneisses formed by the intrusion of gneissic granite of unit 13 into dioritic and tonalitic migmatitic gneisses of unit 1. This unit includes both intrusion breccias formed by this process, as well as other gneisses which show evidence of the partial assimilation of rocks of unit 1 by the gneissic granites. A number of subdivisions occur within unit 12, and are based on the relative proportions of the two phases. These subdivisions are described below.

1. *Unit 12a.* These are migmatitic gneisses where the proportion of unit 13 is greater than that in unit 1. These rocks begin to grade into gneisses of unit 14

when the mafic component can no longer be distinguished as being from unit 1.

2. *Unit 12b.* This unit contains approximately equal proportions of units 13 and 1.
3. *Unit 12c.* The proportion of unit 1 is greater than that of unit 13. These rocks grade into gneisses of unit 1, or represent areas where only small sills of granite are present in unit 1.
4. *Unit 12d.* In this unit, unit 1 is cut by veins and layers of both gneissic granite (unit 13) and gneissic granodiorite (unit 11).

Unit 14 consists of a series of layered gneissic granites, again, probably representing a hybrid rock. Discontinuous layers of mafic rock are abundant, and in this case, the origin of the mafic layers is not known. Again, three subdivisions are recognized in unit 14 on the basis of the abundance of mafic versus granitic material. These are: unit 14a, in which the granite and mafic layers are about equal; unit 14b, in which the granitic layers are more abundant; and unit 14c, in which the mafic layers are more abundant than the granitic layers. The granite layers in unit 14c are recognizable as being part of unit 13. In places, this unit will grade into the migmatitic gneisses of unit 4, particularly where the nature of the granitic phase becomes uncertain. Photo 5 contrasts the difference in appearance between unit 13 and unit 14b.

Unit 13 itself consists of medium- to coarse-grained gneissic granite, which is intruded into rocks of units 1 through 11 in the Fishog subdomain as a series of sills and lenticular plutonic bodies. The unit itself is homogeneous, except for the above-mentioned migmatitic gneisses which form along its contacts. The gneissic granite is resistant to erosion, and forms high ridges in the Fishog subdomain. Country rock is commonly only preserved in topographic lows between the higher, better exposed granite ridges. Unit 13 ranges in composition from monzogranite to syenogranite, but the bulk of the unit is syenogranite. Unit 13 differs from the monzonite plutons of unit 10, apart from the obvious compositional differences, by being relatively inclusion-free and having more sharply defined and distinct contacts. Unit 13 intrusions are also more homogeneous in composition and texture than the monzonite plutons. The only major change that occurs in plutons and intrusions of unit 13 occurs near the CMBBZ. As the contact with the CMBBZ is approached, the gneissic granites of unit 13 become more intensely sheared and grain size is reduced. In addition, a shallow, southeast-plunging lineation becomes apparent in the gneissic granites near the CMBBZ.

The results of chemical analysis of the gneissic granites of unit 13 are presented in Table 8, analyses 9 to 15.

Mylonitic Rocks (unit 15)

Two major mylonite zones occur in the Fishog subdomain. One zone cuts through the eastern shore of Fishog Lake, and runs south from the eastern end of Victoria Lake to the Paleozoic unconformity on the eastern side of Head Lake (Fishog–Victoria lakes mylonite, *see* Figure 5). The other zone extends from the Paleozoic unconformity east of Oak Lake, north to Red Boat Lake and Clear Lake, and then swings northeast towards Black Lake (Red Boat Lake mylonite, *see* Figure 5). Additional mylonite zones of limited extent occur along the Head River between Long and Crooked lakes (Figure 5) and in areas along major faults in the Fishog subdomain (Figure 4). The Fishog–Victoria lakes mylonite zone and the Red Boat Lake mylonite zone are the largest and most extensive exposures of mylonite in the Fishog subdomain. Both these two zones are broadest in the south, being up to 500 m in width, and thin to less than 50 m in the north. This broadening to the south may reflect a slightly deeper erosional level in the south, which exposes more of the root zone of the mylonite zone.

Mylonites of unit 15 are best exposed on the eastern shore of Fishog Lake, where the Fishog–Victoria lakes mylonite zone cuts at an angle a granodiorite body that extends to the south of Fishog Lake (Figure 4). All of the stages of mylonite development (Higgins 1971), from protomylonite (Photo 6) to ultramylonite, can be observed in the granodiorite host as the centre of the zone is approached. Also present on Fishog Lake, within the mylonite zone, are pink, calcite-cemented breccias composed of fragments of ultramylonite and protomylonite. At Fishog Lake, the zone of cataclasis is about 400 m wide. As the mylonite zone is traced to the north of Fishog Lake, it narrows to 50 to 100 m in width, and near Cranberry Lake begins to branch into a number of smaller, subsidiary mylonite zones. These subsidiary zones can only be traced a few hundred metres along strike, and are less than 15 m wide. The main Fishog–Victoria lakes mylonite zone can be traced north to Victoria Lake, gradually becoming narrower, and more difficult to follow.

The Red Boat mylonite zone is similar to the Fishog–Victoria lakes zone, but is less exposed. To a certain extent, the two mylonite zones are also associated with major lithologic changes. The Fishog–Victoria lakes zone marks a major contact between rocks of units 13 and 1. Rocks of unit 1 are not exposed west of the mylonite zone. The Red Boat mylonite zone also occurs at the contact between granites of unit 13 and rocks of unit 1. It is possible that the mylonite zones are related to major fault structures, and that the distribution of unit 1 is due to these faults uplifting or otherwise exposing rocks of unit 1.

The mylonite zones in the Fishog subdomain affect all of the rock types within the Fishog subdomain, except the late pegmatite dikes (unit 32) and possibly the late gabbro of unit 16. The mylonite zones may be related to the development of the CMBBZ, as they are only well developed in the area within 5 km of the CMBBZ.

Mafic Intrusive Rocks (unit 16)

Two late gabbro plugs are located in the Fishog subdomain, one about 2 km northwest of Smudge Lake, and the other 3 km northwest of Scrabble Lake. Both bodies

Photo 6. Protomylonite to blastomylonite developed in a coarse-grained granodiorite on the eastern shore of Fishog Lake.

are composed of quartz-hornblende-plagioclase diorite to gabbro, with a gabbroic texture and a colour index of 60 to 80. The bodies are roughly circular in shape, and about 250 to 400 m across. The body northwest of Scrabble Lake cuts rocks of unit 1, while that northwest of Smudge Lake cuts monzonite of unit 10. The gabbro northwest of Smudge Lake is cut by granite pegmatite dikes of unit 32. The body northwest of Scrabble Lake is not affected by the shearing that is evident in unit 1, and which is probably related to the Fishog–Victoria lakes mylonite zone. The gabbroic plugs may be younger than unit 15. The gabbroic rocks are relatively undeformed compared to adjacent rock when examined in thin section, but they do show a polygonal texture, and have been recrystallized to form the present hornblende-plagioclase mineral assemblage.

MIDDLE PROTEROZOIC

GLAMORGAN GNEISS COMPLEX

Rocks of the Glamorgan Gneiss Complex (Easton 1983, 1987a) outcrop only in the southeastern corner and the east-central part of the map area. Easton (1983, 1987a) divided the Glamorgan Gneiss Complex into two rock suites: an older sodic suite consisting of a number of lithodemic units of mainly tonalite to trondhjemite composition (North American Commission on Stratigraphic Nomenclature 1983, Article 31), and a younger potassic suite consisting of granite gneiss of the Crego Lake Lithodeme. Only rocks of the potassic suite are present in the map area.

Potassic Suite

CREGO LAKE LITHODEME

The Crego Lake Lithodeme (unit 17a) consists of homogeneous monzogranite to syenogranite gneiss, commonly containing 5 to 10 percent magnetite. The rock is leucocratic, and is layered on a centimetre to decimetre scale. The layers are composed of varying amounts of feldspar and quartz. Mafic minerals account for only 2 to 5 percent of the rock, and consist mainly of a greenish biotite, relict after hornblende or pyroxene. In the map area, the unit is also characterized by quartz grains elongated in the plane of the gneissosity. Contacts with the sodic suite rocks are not present in the map area, but in the Howland area to the east the contacts are sharp, and were probably intrusive. The results of an analysis of a potassic suite gneiss from the Howland area is in Table 9, analysis 1.

The contact of the Crego Lake Lithodeme with the Denna Lake Structural Complex is poorly exposed in the map area, and is generally marked by a line of swamps. In general, it is also marked by an increase in the number of pegmatite dikes cutting the lithodeme as the contact is approached. In the east-central part of the map area, the Crego Lake lithodeme is in contact with marble breccia. Although a contact is not exposed in the map area, a contact is exposed on the Davis Lake Road, about 4 km east of the map area (stop 13, Easton et al. 1984). The contact is sharp, but Glamorgan complex rocks at the contact contain large enclaves of mafic material absent from the bulk of the Crego Lake Lithodeme. This enclave-rich zone at the contact is less than 100 m in width.

In the southeast part of the map area, no contact is exposed, and the Crego Lake Lithodeme abuts against grey gneisses of probable metasedimentary origin (unit 18) and granitic gneiss (unit 20). A small anorthosite body is also present along the contact (unit 5); this anorthosite may be related to similar anorthosite bodies found along Highway 121, southwest of Haliburton and adjacent to the northern margin of the Glamorgan

TABLE 9. CHEMICAL ANALYSES FROM THE CREGO LAKE LITHODEME, GLAMORGAN GNEISS COMPLEX, AND FROM METASEDIMENTARY AND METAVOLCANIC ROCKS, DENNA LAKE STRUCTURAL COMPLEX, DIGBY-LUTTERWORTH AREA.

(wt. %)	1	2	3	4	5	6	7
SiO_2	77.10	5.56	75.20	71 60	45.70	45.30	66.40
TiO_2	0.21	0.0	0.06	0.02	2.41	1.22	0.29
Al_2O_3	12.00	0.06	0.30	0.37	11.70	12.20	16.20
Fe_2O_3	2.16	0.0	0.0	0.0	5.83	12.90	0.53
FeO	NR	0.15	0.22	0.29	8.07	NR	1.82
MgO	0.21	21.90	9.94	12.20	5.24	10.60	1.52
CaO	0.84	28.40	12.40	15.20	14.80	10.90	6.42
Na_2O	3.75	0.01	0.14	0.14	2.88	2.66	2.57
K_2O	3.57	0.01	0.00	0.00	0.48	0.85	2.05
P_2O_5	0.02	0.0	0.0	0.0	0.14	0.31	0.06
MnO	0.03	0.05	0.04	0.05	0.25	0.22	0.04
CO_2	0.11	42.30	0.29	0.08	1.07	0.74	0.46
S	0.1	0.01	0.01	0.01	0.54	0.02	0.06
H_2O^+	0.10	0.0	0.53	0.48	0.25	0.0	0.58
H_2O^-	0.0	0.06	0.05	0.0	0.07	0.0	0.04
total	100.01	98.51	99.18	100.44	99.43	97.92	99.04
(ppm)							
Ba	NR	100	NR	NR	90	NR	NR
Co	NR	--	< 5	< 5	36	NR	9
Cr	NR	--	< 10	< 10	97	NR	10
Cu	NR	8	8	< 5	86	NR	7
Li	NR	3	NR	NR	84	NR	NR
Mo	NR	--	< 3	< 3	--	NR	< 3
Nb	6	10	< 5	< 5	35	16	< 5
Ni	NR	--	< 5	< 5	25	NR	< 5
Pb	NR	11	< 10	< 10	19	NR	< 10
Rb	60	6	< 5	6	20	10	33
Sc	3	3	NR	NR	50	21	NR
Sr	90	210	65	60	260	455	45
Th	--	8	< 10	< 10	--	--	< 10
V	6	4	NR	NR	405	275	NR
Y	70	4	< 5	5	50	22	6
Zn	NR	32	88	82	149	NR	41
Zr	150	11	31	30	45	70	100

Notes:

1: 83-RME-0522, syenogranite gneiss, Crego Lake Lithodeme

2: 84-RME-0133, dolomite marble, Highway 503 east

3: 83-RME-1059, stromatolitic, tremolite-quartz dolomite marble, Buller Lake

4: 84-RME-1079, tremolite-quartz dolomite marble, Buller Lake

5: 84-RME-0130, amphibolite (tuff?), Highway 503 east

6: 83-RME-0183, amphibolite (tuff?), Howland area, near Crystal Lake

7: 84-RME-1062, sublitharenite, Buller Road

NR: not reported

--: not detected

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

Gneiss Complex. The contact between the Crego Lake Lithodeme and the Denna Lake Structural Complex in the southeast corner of the map area, shown on Map 2530 (back pocket), represents the boundary between rocks clearly belonging to the Crego Lake Lithodeme and rocks which, although locally of similar composition, are texturally distinct from the Crego Lake Lithodeme.

Rocks lithologically similar to the Crego Lake Lithodeme in the Eels Lake area have been assigned to the Anstruther Lake group of the Grenville Supergroup (Bright 1977, 1980). Bright (1977, 1980) considered these rocks to be metasedimentary in origin, being either remobilized arkose or arenite. Easton (1987a) found no evidence supporting a metasedimentary origin for these rocks, and concluded that they could be of either igneous or metasedimentary origin. As these rocks were intimately associated with the Glamorgan Gneiss Complex, he termed them the Crego Lake Lithodeme, a term with no genetic connotation. If these rocks are ultimately shown to have a metasedimentary origin, then they can be correlated with the Anstruther Lake Group.

If not, they will remain as a mappable unit tentatively assigned to the Glamorgan Gneiss Complex.

For further descriptions of the Glamorgan Gneiss Complex, in particular the sodic suite rocks, the reader is referred to Easton (1987a).

MIDDLE TO LATE PROTEROZOIC

DENNA LAKE STRUCTURAL COMPLEX (UNITS 18 TO 22)

The eastern third of the map area is underlain by a heterogeneous mixture of tectonically disrupted strata, predominantly of metasedimentary parentage, termed the Denna Lake Structural Complex (Easton 1983, 1987a; Figures 4 and 9, this report). Five main rock types are present in the Denna Lake Structural Complex and are shown on Map 2530 (back pocket).

Unit 22: marble tectonic breccias consisting of a coarse-grained, white to pink calcite matrix containing rounded to subrounded inclusions, tens of centimetres to hundreds of metres in size, of siliceous clastic metasedimentary rocks, amphibolites, calc-silicate rocks, layered marbles, and a variety of granitoids (Photo 7); a number of breccia types can be mapped out on the basis of dominant clast type (Photo 8; Figure 8)

Unit 21: dolomite and calcite marbles as layers, lenses, or large blocks within marble breccia; the large area of dolomite marble near Buller Lake (Figure 8) is an example of this occurrence

Unit 20: a variety of granitoid rocks ranging in composition from diorite to syenite, and showing varying degrees of disruption

Unit 19: a variety of siliceous clastic metasedimentary rocks including quartz arenites, wackes, and rusty weathering schists

Unit 18: a suite of unusual gneissic rocks of indeterminate protolith, which include migmatitic rocks (units 18c and 18d) unlike any of the adjacent Glamorgan Gneiss Complex rocks or any Grenville Supergroup strata in the adjacent Howland map area

In addition to the five main units above, a small body of anorthosite (unit 5) is also present at the contact of the Glamorgan Gneiss Complex and the Denna Lake Structural Complex, in the southeast corner of the map area. This unit may not be coeval with anorthositic rocks in the Fishog subdomain. The Denna Lake Structural Complex is also host to numerous syenite and granite pegmatite dikes (unit 32).

All of the above units show varying degrees of tectonic disruption, ranging from their presence as isolated blocks in a marble matrix, to, in the case of intrusive rocks, crosscutting but internally brecciated and cataclastic bodies. Blocks, ranging in size from tens of metres to hundreds of metres, of all units are present within the Denna Lake Structural Complex. Some of the irregular topography in the area underlain by the Denna Lake Structural Complex may reflect large blocks of resistant material within more easily eroded marble breccia. In many respects, the Denna Lake Structural Complex resembles tectonic melanges present in younger orogenic belts, such as the Dunnage Melange (Kay 1976) in central Newfoundland. Instead of having a slate matrix as in the Dunnage Melange, the Denna Lake Structural Complex has a marble matrix, but in many other respects the two are similar.

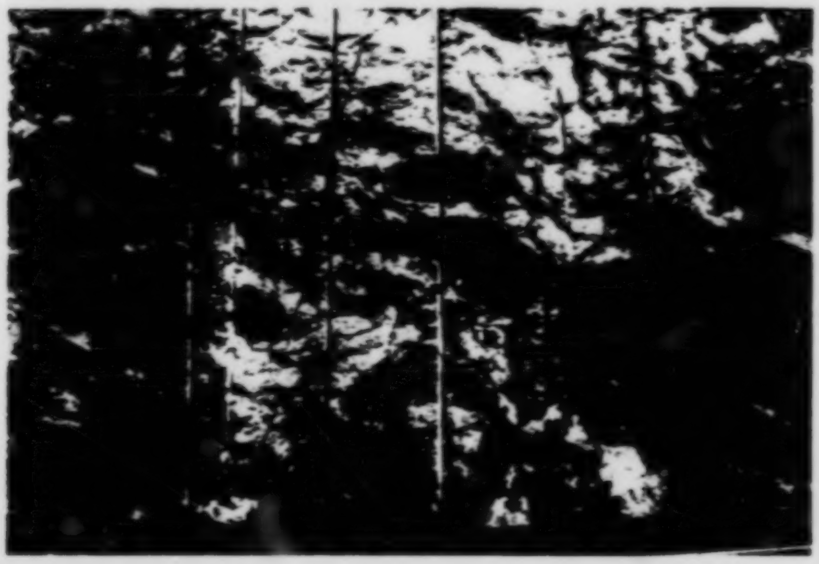


Photo 7. Marble breccia of the Denna Lake Structural Complex at Miners Bay. Large granite block is exposed at bottom centre of photo; large amphibolite and calc-silicate blocks (dark) are present above the granite block. Field of view is about 6 m high by 8 m wide.

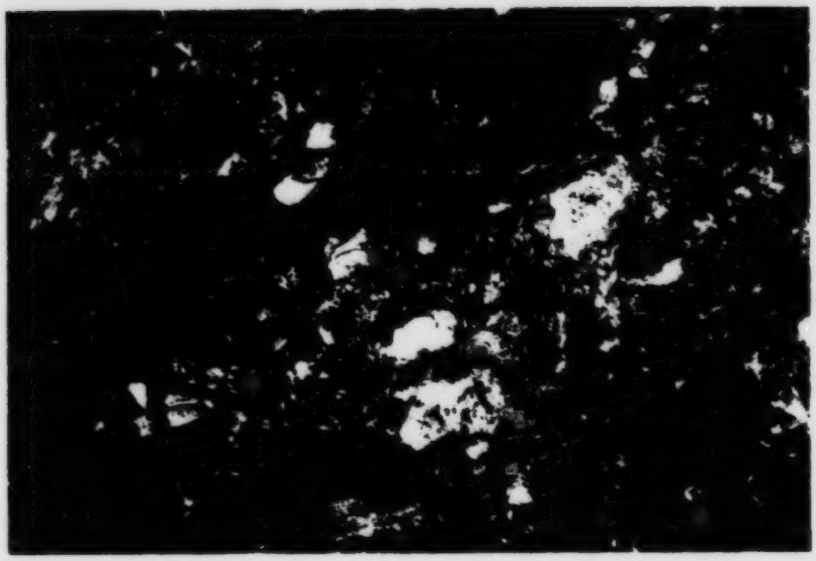


Photo 8. Quartz arenite fragments in marble breccia, Denna Lake Structural Complex, Moore Falls.

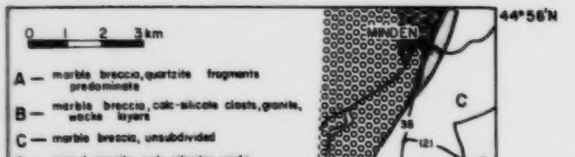

0 1 2 3 km
A — marble breccia, quartzite fragments predominate
B — marble breccia, calc-silicate clasts, granite, wacke layers
C — marble breccia, unsubdivided
D — mixed granite, calc-silicates, wacke
E — layered granitoid rocks
F — dolomite marble
G — dolomite marble with amphibolite layers
H — dolomitic marble, arenite, quartzofeldspathic gneiss
J — granite
K — quartzite, granite, migmatite
MINDEN
35
(21)
GULL LAKE
CMBBZ
CENTRAL ←GNEISS→ BELT
DENNA LAKE STRUCTURAL COMPLEX
GLAMORGAN GNEISS COMPLEX
44°56'N
44°45'N
78°52'W
78°42'W

Figure 8. Lithologic subdivisions within the Denna Lake Structural Complex. Subdivisions are based on dominant clast type in marble breccia units, or dominant rock type(s) within parts of the Denna Lake Structural Complex. These zones may represent a "ghost" stratigraphy preserved within the Denna Lake Structural Complex.

Due to the obviously heterogeneous nature of the Denna Lake Structural Complex, the tectonic disruption observed in this zone, the lack of continuous, mappable stratigraphy, and the presence of marble breccias, it is clear that normal stratigraphic methods are not applicable to this zone. The 1983 edition of the Code of Stratigraphic Nomenclature introduced the term "structural complex" (Article 37, North American Commission on Stratigraphic Nomenclature 1983) for such zones. A "structural complex" is defined thus:

> "In some terranes, tectonic processes (for example, shearing, faulting) have produced heterogeneous mixtures of disrupted bodies of rock in which some individual components are too small to be mapped. Where there is no doubt that the mixing or tectonic disruption is due to tectonic process, such a mixture is designated as a structural complex, whether it consists of two or more classes of rock, or a single class only."

Easton (1983, 1987a) proposed that the marble-rich terrane between the Gull River and the Glamorgan Gneiss Complex was a structural complex as defined above, and named the zone the Denna Lake Structural Complex. Mapping in the Digby–Lutterworth area has confirmed the heterogeneous nature of this zone, as well as the utility of the stratigraphic concept of the "structural complex".

Despite the heterogeneous nature of the Denna Lake Structural Complex, it has been possible to recognize a number of domains or blocks within the complex on the basis of dominant clast type in the marble breccias, or of zones of disrupted but similar rock types elsewhere in the complex. Ten such zones are present within the Digby–Lutterworth area as illustrated in Figure 8. Contacts between the zones are commonly marked by depressions, and may well be faults. In particular, zone F at Buller Lake (Figure 8) is rimmed by a number of graphite occurrences (*see* Figure 26), which may be related to the boundary fault to this block. Two types of zones are present: those dominated by metasedimentary rocks (zones A, B, C, D, F, G and K; Figure 8), and those dominated by granitoid rocks (zones E, J, H and parts of B and K). One striking feature of the Denna Lake Structural Complex is that the metasedimentary strata within the Denna Lake Structural Complex are lithologically similar to Grenville Supergroup rocks exposed southeast of the Glamorgan complex, in the adjacent Howland area (Easton 1983, 1987a).

The Denna Lake Structural Complex is dominated by dolomite marbles, quartz arenites and arenites, and contains few metavolcanic rocks, as is the case in the Grenville Supergroup, 25 km to the east in the Howland area. However, within the Denna Lake Structural Complex, metasedimentary units are not continuous over distances of a few hundred metres, and no stratigraphy (*sensu stricto*) can be established. Figure 9 compares the stratigraphic sequence recognized in the Howland area by the author with the rock types present in the metasedimentary-rich zones of the Denna Lake Structural Complex. Given the extent of the disruption that has occurred in the complex, the similarity with the Howland area is striking. Thus, the metasedimentary rocks in the Denna Lake Structural Complex may preserve a "ghost" stratigraphy. As discussed in greater detail in the section "Economic Geology", this observation has a bearing on the types of mineral deposits likely to be present in the Denna Lake Structural Complex, and the areas most favourable to exploration for metallic mineral deposits.

The granitoid rocks present in the Denna Lake Structural Complex are also lithologically similar to the diorite, gabbro and granodioritic rocks present in the southeast part of the Howland area, except that they are internally brecciated and cataclastic, and do not define plutonic bodies with discrete contacts as do plutons in the Howland area (Figure 10). Photo 9 shows some of the granitoid rocks of the Denna Lake Structural Complex exposed in a roadcut on Highway 35, 1 km north of Miners Bay. These rocks are internally brecciated, and the dark, horizontal bands visible on the outcrop are highly strained layers of paragneiss that are interleaved with the granitoid rocks.

Some parts of the Denna Lake Structural Complex warrant additional comment. What follows is a brief description of the major rock units that constitute the Denna Lake Structural Complex (units 18 to 22). Significant features or structures within the Denna Lake Structural Complex are discussed under the relevant lithologic unit.

Granitoid Gneisses of Indeterminate Protolith

This unit consists of a variety of quartzofeldspathic gneisses (unit 18) which locally exhibit textural and compositional features indicative of a metasedimentary origin. These rocks are unlike any of the metasediments found in the Grenville Supergroup to the east. In addition, this unit also includes a number of quartzofeldspathic gneisses of indeterminate protolith. Apart from the southeast corner of the map area, these rocks are of limited areal extent.

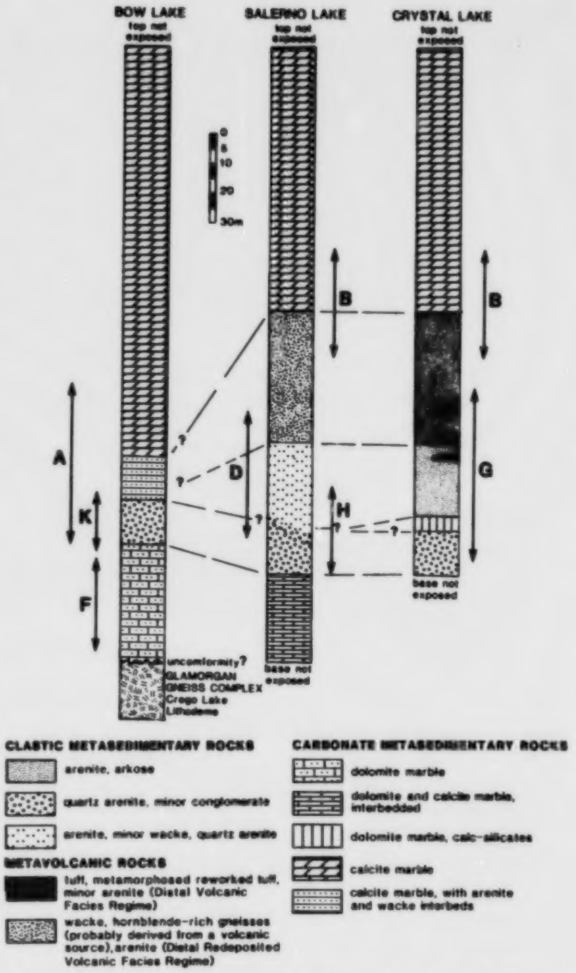

BOW LAKE
top not exposed
SALERNO LAKE
top not exposed
CRYSTAL LAKE
top not exposed
0
5
10
20
30m
A
B
B
D
F
G
H
K
?
uncomformity?
GLAMORGAN GNEISS COMPLEX
Crego Lake Lithodeme
base not exposed
base not exposed
CLASTIC METASEDIMENTARY ROCKS
arenite, arkose
quartz arenite, minor conglomerate
arenite, minor wacke, quartz arenite
METAVOLCANIC ROCKS
tuff, metamorphosed reworked tuff, minor arenite (Distal Volcanic Facies Regime)
wacke, hornblende-rich gneisses (probably derived from a volcanic source), arenite (Distal Redeposited Volcanic Facies Regime)
CARBONATE METASEDIMENTARY ROCKS
dolomite marble
dolomite and calcite marble, interbedded
dolomite marble, calc-silicates
calcite marble
calcite marble, with arenite and wacke interbeds

Figure 9. Comparison of stratigraphic sections from the Howland area (undisrupted Grenville Supergroup strata) with dominant metasedimentary sequences present within parts of the Denna Lake Structural Complex. Letters A to K refer to zones illustrated in Figure 8. Note overall similarity between the "ghost" stratigraphy preserved in the Denna Lake Structural Complex and that present in the Howland area. The Howland sections are located 25 km east of the map area and are from Easton (1987a).

Thinly to thickly layered, biotite quartzofeldspathic schists, arkoses, and quartz arenites, with layers of granite and granodiorite (units 18a and 18b) (Photo 9), are exposed on two small hills located 500 m north and south of Miners Bay, along Highway 35. In these units, the granitic rocks appear, at least in part, to be tectonically mixed with the metasedimentary rocks, rather than to be intrusive into them. These units may represent a disrupted plutonic margin. They only occur at Miners Bay, and are of limited extent.

Along the Davis Lake Road, by the east-central boundary of the map area, is found a series of outcrops of a migmatitic, medium- to coarse-grained, pink to buff, quartzofeldspathic biotite gneiss, which contains a

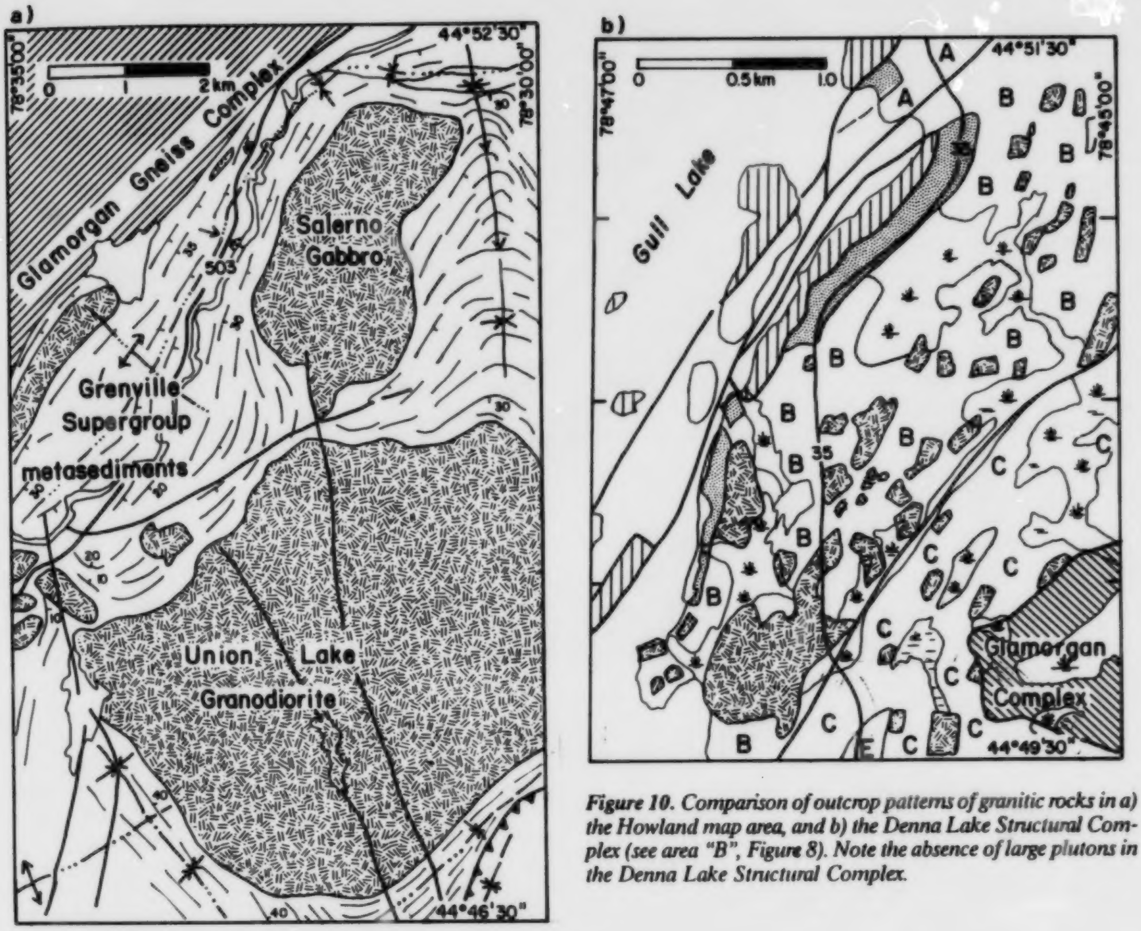

a)
78°35'00"
0
1
2 km
44°52'30"
78°30'00"
Glamorgan Gneiss Complex
Salerno Gabbro
503
35
30
Grenville Supergroup metasediments
20
10
Union Lake Granodiorite
40
44°46'30"
b)
78°47'00"
0
0.5 km
1.0
44°51'30"
78°45'00"
Gull Lake
A
B
C
35
Glamorgan Complex
44°49'30"

Figure 10. Comparison of outcrop patterns of granitic rocks in a) the Howland map area, and b) the Denna Lake Structural Complex (see area "B", Figure 8). Note the absence of large plutons in the Denna Lake Structural Complex.

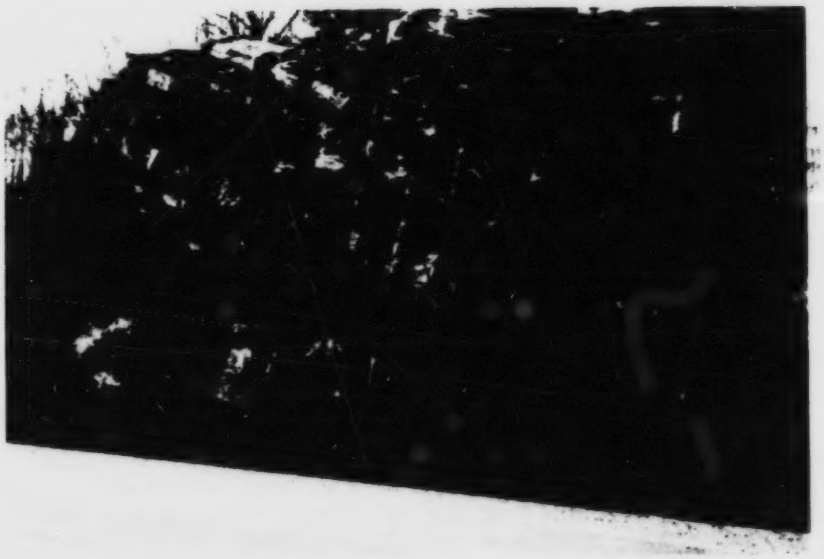


Photo 9. Disrupted granitoid rocks tectonically mixed with wacke and arenite layers (dark bands) on Highway 35, 500 m north of Miners Bay.

leucosomal phase not seen in other rocks in the area (unit 18c). The ridge continues east into the Howland area, where these rocks were first described by Easton (1987a). These rocks may be of metasedimentary origin, but are unlike any Grenville Supergroup rocks to the east, and contain a mobilizate phase absent in the adjacent rocks.

Unit 18d is also migmatitic, and consists of a fine- to medium-grained, grey, quartzofeldspathic gneiss with a granodiorite mobilizate containing a folded gneissosity. This unit also occurs in the Howland area (Easton 1983, 1987a). It outcrops in the map area west of South Beaver Lake, and in a few scattered localities near East Moore Lake. As is the case with unit 18c, it has no counterpart in the Grenville Supergroup to the east, and has an early mobilizate phase.

Most of the quartzofeldspathic gneisses of unit 18 are exposed along the contact with the Glamorgan Gneiss Complex in the southeast corner of the map area. These rocks consist of grey, thinly to thickly layered quartzofeldspathic gneisses of tonalite composition, containing layers of felsite, quartz arenite, and massive to foliated granodiorite and quartz diorite (units 18f and 18g). Unit 18f is associated with grey, gneissic quartz diorite, generally fine to medium grained (unit 18e), and leucocratic granitic gneisses, which could be related to units 17a (Glamorgan Gneiss Complex) or 20. These rocks contain some layers which are clearly metasedimentary in origin, containing 60 to 70 percent quartz, but also grey, tonalitic gneisses found nowhere else in the area. These gneisses are unlike any of the gneisses characteristic of the sodic suite of the Glamorgan Gneiss Complex, although they could be a sedimentary sequence derived from gneisses such as those in the Glamorgan Gneiss Complex. It is also possible that these rocks represent a dismembered pluton of the diorite/gabbro suite that is found intruding Grenville Supergroup rocks in the Howland area. The contact between rocks of the Crego Lake Lithodeme and these quartzofeldspathic gneisses is marked by a line of swamps. However, in one locality, a small body of anorthosite and anorthositic gabbro (unit 5) occurs along the contact. It is also possible that the quartz diorites of unit 18e may be related to the anorthositic rocks, as quartz diorites are found in association with the anorthosites of the Fishog subdomain.

Siliceous Clastic Metasedimentary Rocks

This unit consists of a variety of siliceous clastic metasedimentary rocks (unit 19) probably derived from Grenville Supergroup strata. Three basic varieties are present:

1. quartzose clastic metasedimentary rocks including arkose (unit 19a); felsite, probably derived from arkose (unit 19b); feldspathic litharenite (unit 19c); fine-grained quartzose felsite, probably derived from arenite (unit 19d); quartz arenite (unit 19e); and medium to coarse-grained felsite, derived either from arkose or leucogranite (unit 19j)
2. micaceous clastic metasedimentary rocks, including wacke (unit 19f); biotite quartzofeldspathic schist, probably derived from wacke (unit 19g); hornblende-biotite-plagioclase-quartz schist, possibly representing reworked mafic and intermediate tuff (unit 19h); and amphibolite and quartz-hornblende-biotite-plagioclase schist (unit 19k), which may be derived from tuff and reworked tuff with interbedded calc-silicate rock
3. rusty weathering, quartzofeldspathic schist containing pyrite and pyrrhotite, and locally other sulphide minerals (*see* "Economic Geology", *subsection*, "Sulphide Mineralization")

As shown in Figure 9, all of these units have lithologic counterparts in the Grenville Supergroup strata in the adjacent Howland area. In the present area, metamorphic grade is higher (upper amphibolite facies), and sedimentary and other primary textures are less preserved than in the Howland area (low to middle amphibolite facies).

The quartz arenite and related quartzose clastic metasedimentary rocks are resistant to erosion and readily form blocks, occurring as high ridges and discrete hills within marble breccia (e.g., west of Buller Road; Map 2530, back pocket). They are most abundant along the electric power transmission line west of South Beaver Lake, and also along the Buller Road. Granitoid rocks of unit 20 are commonly associated with the quartz arenites, and form blocky breccias where the two are in contact. These breccias appear to have formed prior to tectonic disruption of the Denna Lake Structural Complex. The results of chemical analysis of a sublitharenite from the map area is presented in Table 9, analysis 7.

The wackes and amphibolitic rocks are most common along the Buller Road, and are found in association with dolomite marbles and arenites and sublitharenites. In this regard, they resemble similar rocks in the Crystal Lake region of the Howland area. Whereas the quartzose metasedimentary rocks form blocky outcrops, the wackes and related rocks form discontinuous bands which have a northeast trend along the Buller Road. The wackes and amphibolitic rocks are thinly layered, and layering reflects probable primary compositional differences between layers. Primary textures are not well preserved, and in the case of the amphibolitic rocks, composition is the primary reason for suggesting that some of these rocks may be derived from tuffs, or reworked tuffs. These rocks are associated with a number of sulphide occurrences, which may also reflect some original volcanogenic component to these rocks. The results from chemical analysis of one of these rocks is presented in Table 9, analysis 5. An analysis of a reworked tuff from the Howland area is also presented in Table 9, analysis 6, for comparison.

The distribution of the clastic metasedimentary rocks in the Denna Lake Structural Complex is shown in Figure 8. In Figure 9, stratigraphic sections from the Howland area are compared with metasedimentary sequences observed in the Denna Lake Structural Complex.

Granitoid and Related Rocks

Granitoid rocks (unit 20) underlie much of zones B, K and J in the Denna Lake Structural Complex (Figure 8) and are locally abundant in other parts of the complex (Map 2530, back pocket). Rocks of this unit range from granodiorite to syenogranite in composition, and are mainly monzogranites. Many of the outcrops of granitoid rocks have cataclastic textures (protomylonites), particularly near the margins of the bodies. No contact metamorphic effects were observed near contacts with marbles or metasedimentary rocks. In the Howland area, skarns are commonly found at the margins of the diorite and granodiorite plutons. Also, unlike their counterparts in the Howland area southeast of the Glamorgan Gneiss Complex, granitoids in the Denna Lake Structural Complex do not show outcrop patterns typical of mesozonal to epizonal plutons (Figure 10). Close examination of Map 2530 (back pocket) also indicates that the areas underlain by these granitoid rocks are not continuous, but that the granitoids have been dismembered (e.g., areas B or K, Figures 8 and 10); these areas also include patches of metasedimentary rocks. Areas of marble breccia commonly separate blocks of granitoid rock. Thus, it seems likely that the areas underlain by granitoid rocks in the Denna Lake Structural Complex are not plutonic bodies intrusive into the complex, but instead represent plutons that are intrusive into Grenville Supergroup strata and that were subsequently disrupted during the formation of the Denna Lake Structural Complex and the CMBBZ.

Carbonate Metasedimentary Rocks

Carbonate metasedimentary rocks are subdivided on the basis of CaO:MgO ratio, determined in the field using acid. Field designations have been confirmed by subsequent chemical analysis. The primary distinction is between calcite and dolomite marbles. Other subdivisions are made on the basis of grain size, type and scale of bedding/layering, interlayering with other marble types, and accessory mineralogy. The subdivisions recognized in the map area are listed below:

Unit 21a: medium to coarse-grained, massive calcite marble

Unit 21b: medium to coarse-grained, massive calcite marble containing tremolite and diopside

Unit 21c: interbedded calcite and dolomite marble, thinly layered

Unit 21d: calcite and dolomite marble, not interbedded

Unit 21e: massive dolomite marble, which along with unit 21f is the most extensive unbrecciated carbonate unit

Unit 21f: massive dolomite marble, tremolite-diopside-quartz bearing

Unit 21r: rusty weathering, silicified dolomite marble

The results of chemical analysis of marbles from the Denna Lake Structural Complex are presented in Table 9, analyses 2, 3 and 4; and in Table 16.

Carbonate metasedimentary rocks (nonbrecciated) only occur in abundance in three areas of the Denna Lake Structural Complex, and all are composed of dolomite marbles (Figure 8). Of these, the largest and best exposed is on and south of Buller Lake. A smaller band of dolomite marbles is exposed along the Davis Lake Road near the east-central boundary of the map area (Figure 8). A third band is associated with amphibolitic and siliceous metasedimentary rocks along the Buller Lake Road (Figure 8).

On the south shore of Buller Lake, coarse-grained dolomite marbles (now mainly tremolite) form a 500 by 1000 m block within the Denna Lake Structural Complex. The marbles contain millimetre to centimetre scale silica segregations (Photo 10). These segregations resemble similar structures in low metamorphic grade Grenville Supergroup marbles that have been interpreted by John Moore and others (Bartlett et al. 1984) to be algal mats (stratiform stromatolites) (Photo 10). If the structures in the Buller Lake area are similar in origin to those observed at lower metamorphic grade, then they indicate that algal structures may be preserved at high metamorphic grades (upper amphibolite facies, in this instance). Similar structures are also present in dolomite marbles at Bow Lake in the adjacent Howland area, which is consistent with the stratigraphic correlation suggested in Figure 9.

Marble Tectonic Breccia

A number of marble breccia units have been mapped in the Denna Lake Structural Complex on the basis of the dominant fragment type. These include:

Unit 22a: marble breccia with no dominant fragment type

Unit 22b: marble breccia with quartz arenite fragments predominant

Unit 22c: marble breccia with 10 to 25 percent calc-silicate (diopside-quartz assemblages) fragments

Unit 22d: marble breccia with 50 cm to 1 m thick layers of calc-silicate material and siliceous clastic metasedimentary rocks with 10 to 30 percent granitic layers

Unit 22e: marble breccia with abundant amphibolite blocks, rusty weathering blocks and layers, and locally with a dolomite and calcite matrix

All marble breccia types are exposed in roadcuts along Highway 35 between Moore Falls and the northern boundary of the map area. The spectacular roadcut at Miners Bay illustrates the variation of rock types and textures in the marble breccias very well, and in some respects, represents the Denna Lake Structural Complex in microcosm.

The amount of marble breccia within the Denna Lake Structural Complex is probably underestimated on Map 2530 (back pocket). Within any large marble breccia outcrop, fragment-poor and fragment-rich areas are present. On small outcrops in the bush, fragment-poor outcrops have possibly been mapped as carbonate metasedimentary rock (unit 21) rather than as marble breccia.

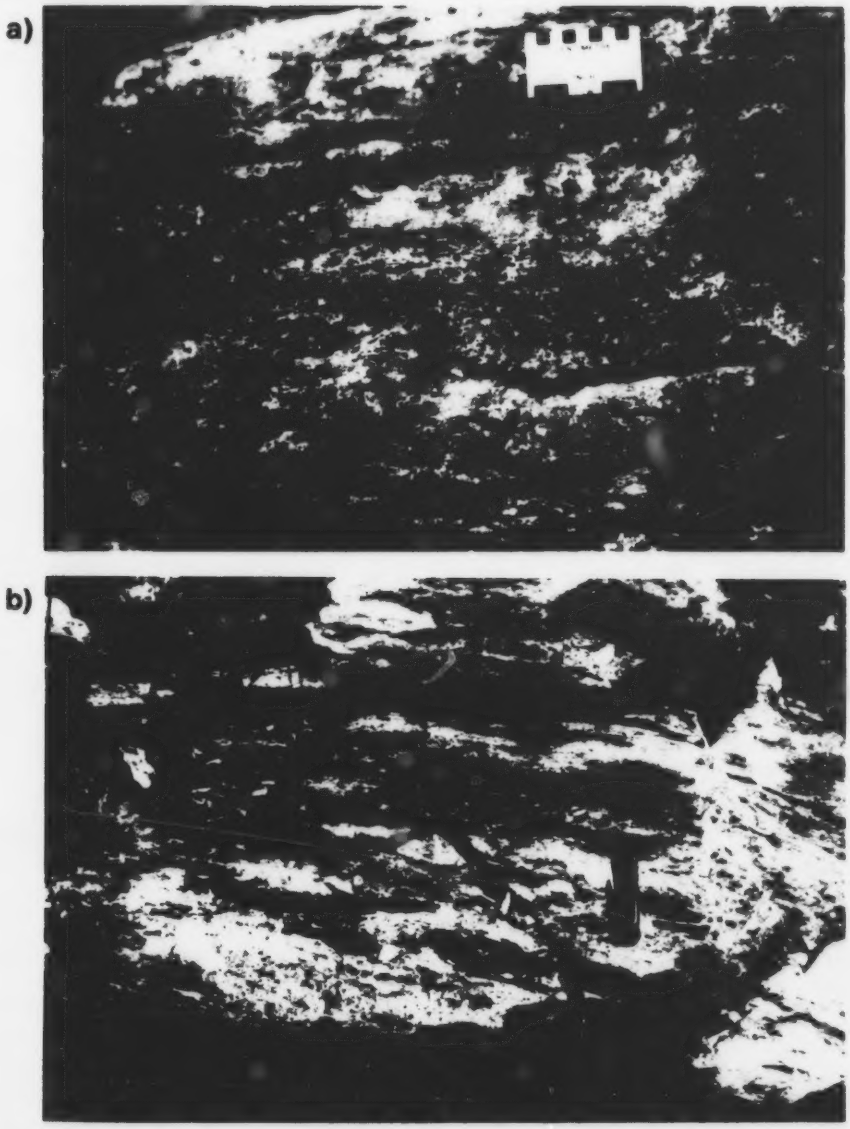


Photo 10. Quartz segregations in a) dolomite marble, south shore of Buller Lake, upper amphibolite facies; b) stromatolitic dolomite marble, Kaladar area, greenschist facies. Note the similarity between the structures. Both structures have been interpreted to represent metamorphosed algal mats.

ROCKS IN THE CENTRAL METASEDIMENTARY BELT BOUNDARY ZONE (CMBBZ) (UNITS 23 TO 30)

The Central Metasedimentary Belt Boundary Zone (CMBBZ) (Davidson et al. 1984) is a 2 to 6 km wide, north- to northeast-trending zone of cataclastic and disrupted quartzofeldspathic gneisses that separate rocks of the Central Gneiss Belt to the west from rocks of the Central Metasedimentary Belt to the east. Tectonic disruption within the CMBBZ is intense enough to make determination of the protolith of gneisses within the CMBBZ impossible in almost all instances. In contrast, protolith is evident in rocks of the adjacent Fishog subdomain.

The CMBBZ in the map area is considerably wider in the north (6 km) than in the south (2 km), a difference also reflected in the variety of rock units that can be mapped across the CMBBZ (Figure 11). The CMBBZ widens near Moore Falls. North of Moore Falls, the CMBBZ has a different aeromagnetic signature than it does south of Moore Falls (*see section on* "Aeromagnetic Data"), and this difference in magnetic signatures may in part reflect the compositional changes in the CMBBZ from north (more mafic units) to south (more felsic units). Aeromagnetic patterns in the area do not

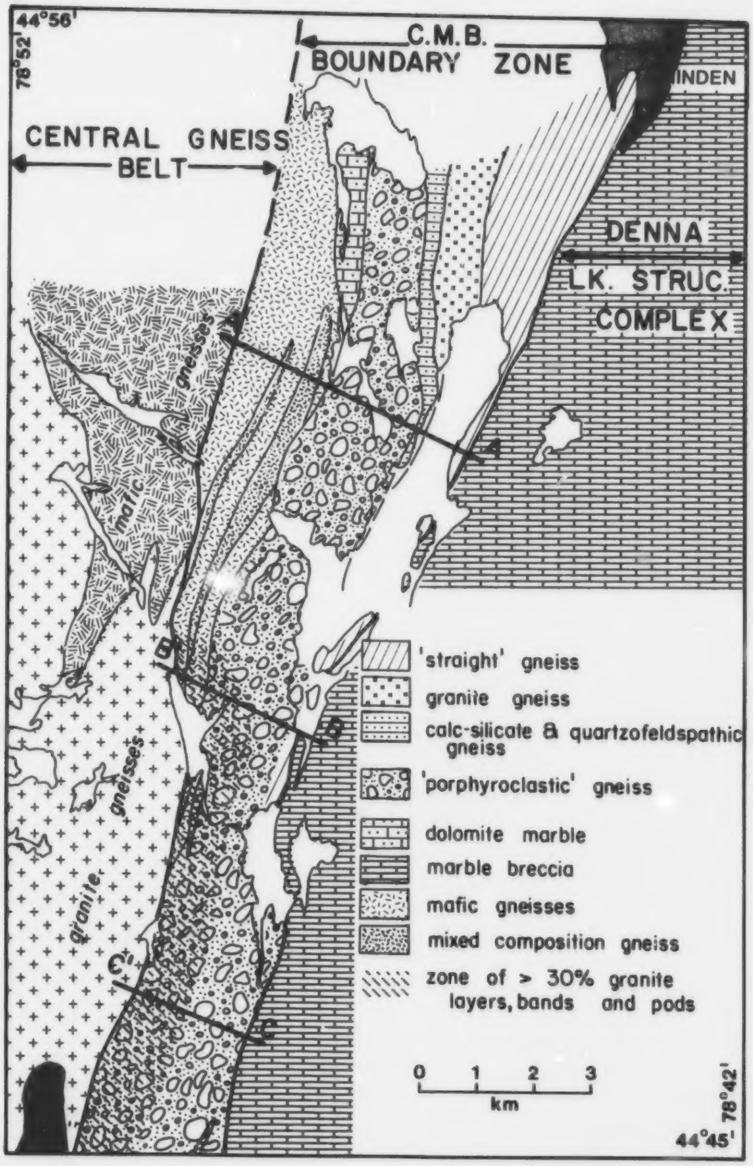

44°56'
78°52'
C.M.B.
BOUNDARY ZONE
CENTRAL GNEISS
BELT
INDEN
DENNA
LK. STRUC.
COMPLEX
A
A'
B
B'
C
C'
mafic gneisses
granite gneisses
'straight' gneiss
granite gneiss
calc-silicate & quartzofeldspathic gneiss
'porphyroclastic' gneiss
dolomite marble
marble breccia
mafic gneisses
mixed composition gneiss
zone of > 30% granite layers, bands and pods
0 1 2 3
km
78°42'
44°45'

Figure 11. Lithotectonic subdivisions of the CMBBZ in the Digby–Lutterworth area. Lines A-A', B-B' and C-C' show the location of the sections described in the text and shown on Figure 12.

parallel the margins of the CMBBZ, but cut across the CMBBZ. This may indicate that the CMBBZ does not separate two fundamentaly different segments of the crust.

It has been possible to recognize a number of mappable units within the CMBBZ (Figure 11). These subdivisions are based on a number of factors, including bulk rock composition, scale and nature of layering, distinctive textural and structural features (as described by Davidson et al. 1982, 1984; Culshaw et al. 1983; and Hanmer and Ciesielski 1984), and in places, exotic mineralogy. Because of the complex geology of the CMBBZ, and the importance of cataclastic and tectonic processes within it, a number of new terms have been introduced by Davidson et al. (1982, 1984), Culshaw et al. (1983) and Hanmer and Ciesielski (1984) to describe tectonic gneisses (tectonites) within the CMBBZ. These terms have proven useful in mapping within the CMBBZ. Some of the more important terms, as defined by Hanmer and Ciesielski (1984) are defined below:

Transposed gneiss. It consists of continuous (over tens of metres), parallel-sided, centimetre-thick layers of leucocratic granitoid and amphibolite gneiss with layers of more intermediate composition. It is very fine grained.

Porphyroclastic gneiss. It consists of a background gneiss of varied composition (quartzofeldspathic to amphibolitic to aluminous) containing isolated potassium feldspar and plagioclase (also locally, garnet and apatite) inclusions, feldspar aggregates and streaks aligned in the foliation. In some outcrops, mechanical and mineralogical disaggregation from pegmatite to isolated feldspar inclusions can be observed. Thus, some feldspars are porphyroclasts. However, in other instances, some of the feldspars may be porphyroblasts. Whatever their origin, isolated feldspar augen are diagnostic of this unit. The groundmass is very fine grained.

Straight gneiss. A useful field term to designate a well-layered gneiss whose layering is not as rectilinear as that in a transposed gneiss, but which contains few discordant features typical of irregularly layered gneisses of the CMBBZ. Again, these rocks are very fine grained.

Block gneiss. Block gneisses generally consist of amphibolite blocks or layers in a less competent quartzofeldspathic matrix.

The tectonite gneiss units described above are migmatitic in many instances. Migmatization may follow tectonite formation, or the leucosome itself may be flattened and become a part of the layering in the tectonite.

The eastern contact of the CMBBZ with the Denna Lake Structural Complex is sharp, and is exposed on a cottage access road just off of Highway 35 near the northeast boundary of the map area. Marble breccia of the Denna Lake Structural Complex passes abruptly into granitic rocks showing highly attenuated quartz grains, layers of feldspar augen, and isoclinal folds. Further down section, the granitic rocks grade into straight gneisses. Granitoid rocks (unit 20) do not show as much tectonic disruption and strain as do the gneisses here. This contact can be traced south along the east shore of Gull Lake for several hundred metres, and from there through islands in the lake to Moore Falls. South of Moore Falls the contact is buried for the most part by glaciofluvial deposits along the Gull River.

The western contact of the CMBBZ in part corresponds to the Boshkung shear zone of Schwerdtner and Mawer (1982). The Boshkung shear zone in the northern part of the map area is represented by a block gneiss containing, at least locally, fragments of diorite, tonalite and gabbro, commonly with a matrix of pegmatite. The shear zone is also cut by late plutons of unit 31. The Boshkung shear zone also represents a deformational front, with rocks west of the shear zone, although deformed, recognizable and traceable into less deformed rocks of the Fishog subdomain. East of the shear zone, rocks typical of the CMBBZ are found. The Boshkung shear zone does not have a significant topographic expression, and in the southern part of the map area, it is difficult to trace because of the presence of similar rock types on both sides of the shear zone, and because of poor outcrop exposure.

In general, there is a threefold division of rock types across the CMBBZ, both in the north and south. From east to west are found, first, 100 to 2000 m of well-layered "transposed" and "straight" gneisses, then 500 to 1500 m of "porphyroclastic" gneisses, and then 500 to 2000 m of gneisses which have some attributes of the gneisses directly opposite in the Fishog subdomain. It should be noted that these zones do not consist of a single unit of gneiss, but several different gneisses which commonly show a lensoid appearance when mapped out.

Starting at the Denna Lake Structural Complex–CMBBZ contact on the northeast shore of Gull Lake, the author will describe the succession of rock types observed in the CMBBZ as one goes down the structural section towards the CMBBZ–Fishog subdomain contact. In addition to outlining the section, this also provides an opportunity to describe the rock types that constitute the CMBBZ in the map area. The section has a 6 km apparent width on the surface in this part of the CMBBZ, and average dips are about 20° to the southeast. Therefore, the section is only about 2 km thick. Figure 12 summarizes the section described below, and contrasts it with the section for the southern part of the map area.

- Denna Lake Structural Complex, about 100 m or more of marble breccia; in this area quartz arenite fragments predominate, in addition to layers and lenses of quartz arenite.
- Denna Lake Structural Complex–CMBBZ contact
- about 150 m of thinly to medium layered granite gneiss, with strongly attenuated quartz grains, less than 10 percent biotite-rich mafic layers
  This unit (unit 23a) is an irregularly layered gneiss grading into a straight gneiss. To the north, the lower 75 m of the unit contains up to 50 percent mafic layers consisting of a biotite-garnet gneiss, and locally, some of the granitic layers are porphyroclastic gneisses (unit 23b). In the Moore Falls–Miners Bay area, unit 23 is overlain by about 10 m of marble breccia, which is in turn overlain by 30 m of thinly to thickly layered, irregularly layered to straight gneiss containing up to 50 percent biotite-rich mafic layers, but little garnet (unit 24) (Figure 12).
- 10 to 20 m of marble breccia with no dominant fragment type
- about 600 m of porphyroclastic gneiss, locally containing pods of irregularly layered gneiss grading into straight gneiss or porphyroclastic gneiss, and layers of straight to transposed gneiss (Photos 11, 12 and 13)
  This unit (unit 25) shows the most evidence for severe tectonic disruption within the CMBBZ. In the north, a 50 m thick lens of porphyroclastic gneiss is present along the western shore of Gull Lake. It is possibly derived from a metasedimentary protolith,

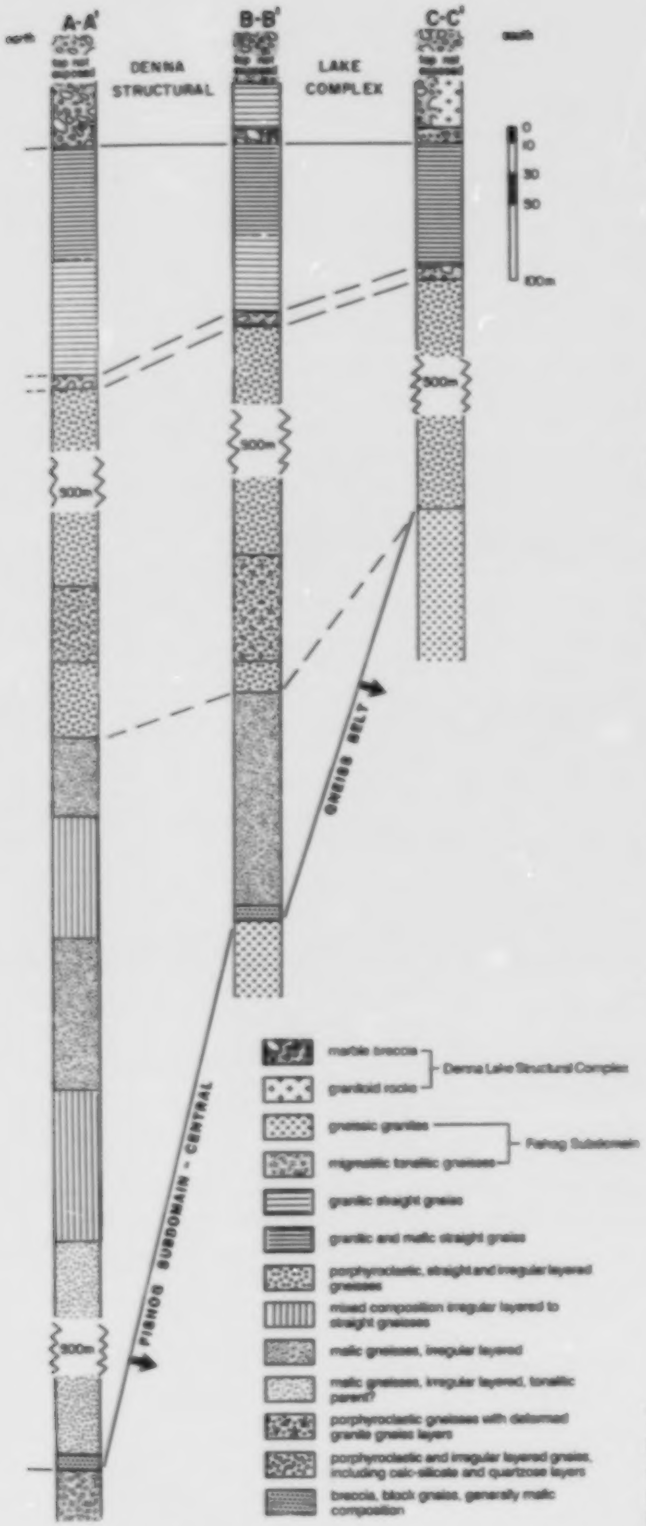

north
A-A'
B-B'
C-C'
south
top not exposed
DENNA STRUCTURAL
LAKE COMPLEX
0
10
30
50
100m
500m
GNEISS BELT
FISHOG SUBDOMAIN - CENTRAL
marble breccia
granitoid rocks
Denna Lake Structural Complex
gneissic granites
migmatitic tonalitic gneisses
Fishog Subdomain
granitic straight gneiss
granitic and mafic straight gneiss
porphyroclastic, straight and irregular layered gneisses
mixed composition irregular layered to straight gneisses
mafic gneisses, irregular layered
mafic gneisses, irregular layered, tonalitic parent?
porphyroclastic gneisses with deformed granite gneiss layers
porphyroclastic and irregular layered gneiss, including calc-silicate and quartzose layers
breccia, block gneiss, generally mafic composition

Figure 12. Lithologic types present in three sections across the CMBBZ in the Digby–Lutterworth area. See Figure 11 for location of the sections. Section A-A' (northernmost section) is described in detail in the text.

as indicated by an abundance of calc-silicate and quartz-rich layers, and abundant biotite and sillimanite (unit 27). To the north this unit becomes more of a straight gneiss.

- about 50 m of porphyroclastic to irregularly layered gneiss, again of possible metasedimentary origin
  These rocks (unit 27) consist almost totally of mafic rock, generally biotite-rich, and thinly layered. Where granitic material is present, it occurs as "clots" of mobilizate within the mafic gneiss (unit 27e; Photo 14). This unit occurs as a lens in the porphyroclastic and irregularly layered gneisses of unit 25.
- about 50 m of porphyroclastic and irregularly layered gneiss (unit 25)
- about 50 m of medium- to coarse-grained, thinly to thickly layered gneisses of amphibolite to gabbro to anorthositic gabbro, with locally preserved igneous textures
  This unit (unit 28b) consists of irregularly layered gneisses and block gneisses.
- about 50 to 100 m of gneisses of mixed composition
  Previous gneiss units have had a single overall bulk composition (e.g., the mafic gneisses of unit 28), or have consisted mainly of two components, granitic material and mafic layers (unit 23). This unit (unit 29), however, consists of layers of various rock types, and is an irregularly layered to straight gneiss, with an overall intermediate composition.
- about 100 m of fine- to medium-grained, thinly to medium-layered mafic gneisses of amphibolite to diorite composition, locally containing isolated augen of feldspar and garnet (possibly porphyroblasts) in a fine-grained matrix (unit 28b)
- about 100 to 150 m of compositionally varied, irregularly layered gneiss, containing roughly equal proportions of granite and mafic layers
- about 500 to 600 m (in the north, the unit pinches out at Black Lake) of mafic, dioritic to tonalitic, migmatitic, irregularly layered gneiss which may be a more intensely deformed equivalent of unit 1
  It is within this unit (unit 30) that are found block gneisses and breccias associated with the Boshkung shear zone, which occurs along the western edge of this unit. Dips steepen from about 20 to 70° to the southeast as the contact with the Fishog subdomain is approached. Small lenses of other types of gneisses, particularly mixed composition, irregularly layered gneisses of unit 29, occur as lenses within unit 30. This unit is cut by granitic bodies of unit 31.

To the south, the section is truncated by the contact with the Fishog subdomain (Figures 11 and 12). At the northern boundary of the map area, unit 30 is about 600 m thick (Figure 11 and 12). To the north, the section has been truncated at Black Lake; unit 28b occurs at the contact with the Fishog subdomain (Figures 11 and 12). Also, on the eastern shore of Black Lake, gneisses of unit 25 have been intruded by a number of granitic sills 50 to 300 cm thick. The granite is very fine grained, and

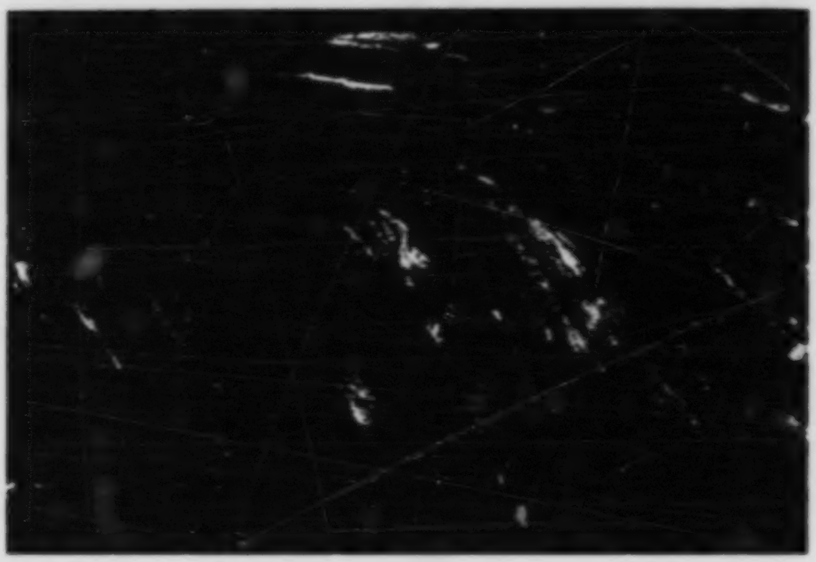


Photo 11. Irregularly layered to straight gneiss of unit 25, CMBBZ. Some layers are porphyroclastic gneiss. Exposure in gravel quarry 1 km north of Moore Falls off Haliburton County Road 2.

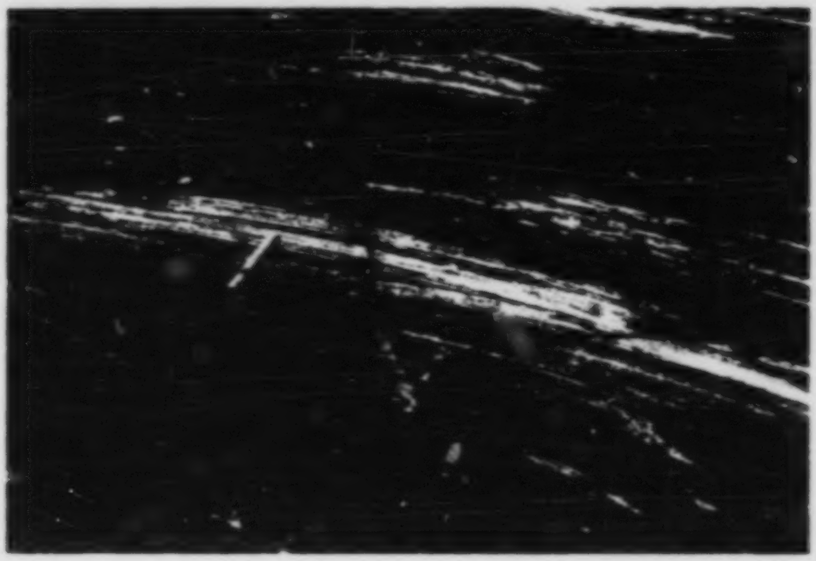


Photo 12. Irregularly layered to straight gneiss of unit 25, CMBBZ. Exposure in gravel quarry, 1 km north of Moore Falls off Haliburton County Road 2.

has been injected along gneissosity. It has undergone subsequent deformation with the host rock. The rock has an overall granitic composition, and has been mapped as unit 26. It is this unit that is quarried for flagstone at Black Lake.

South of Moore Falls, the section is considerably thinner (Figure 12). It consists of about 100 m of unit 23, about 10 or 15 m of marble, and about 600 m of porphyroclastic, irregularly layered and straight gneisses (unit 25). Near the contact with the Fishog subdomain, the percentage of granitic rocks in unit 25 increases greatly, from about 40 percent of the rock to 75 percent. This is noteworthy, as the CMBBZ is in contact with granite rocks in the Fishog subdomain in this area. In the north, where adjacent Fishog subdomain rocks are mafic in composition, mafic rocks of unit 30 are present in the CMBBZ adjacent to the contact. Thus, the lower part of the CMBBZ may be composed of rocks derived from the adjacent Fishog subdomain. There may be other evidence for this. As discussed in the section "Aeromagnetic Data", the magnetic signature of the southern part of

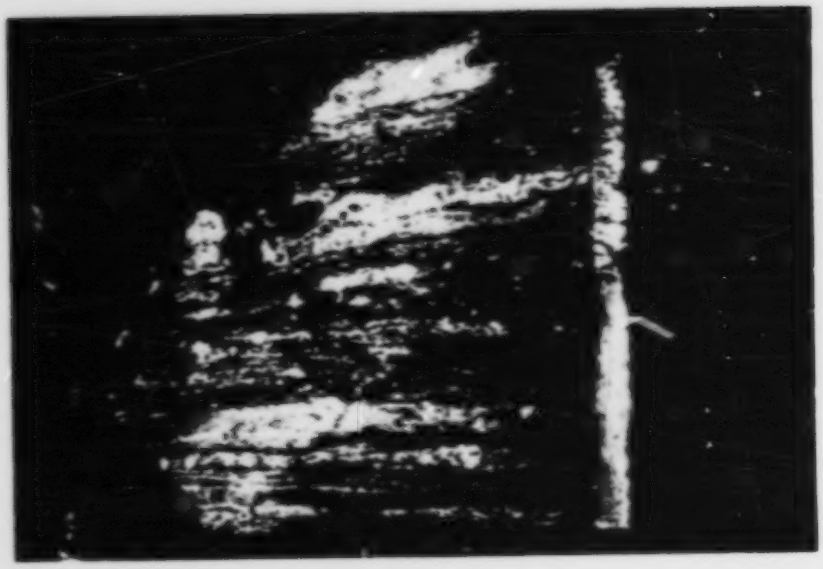


Photo 13. Porphyroclastic gneiss of unit 25, CMBBZ, Haliburton County Road 2, north shore of Pigeon Lake.

Photo 14. Clotted gneiss of unit 27e, CMBBZ. These clots may be local anatectic sweats.

the CMBBZ is similar to that of the neighbouring Fishog subdomain. The same is true for the northern part of the CMBBZ; however, the northern and southern parts of the CMBBZ are very different in magnetic character. This may be related to the source of some of the rocks in the CMBBZ, and may reflect the presence of some Fishog subdomain rocks in the CMBBZ.

It should also be noted that marble occurs in parts of the CMBBZ as well (Figures 11 and 12). Near the top of the section in Gull Lake, marble breccia zones up to 10 m wide occur in the section. North of Little Bob Lake along Haliburton County Road 2, just north of the map area, about 30 m of dolomite marble (unbrecciated, relatively pure) (Photo 15) and about 10 m of sillimanite-garnet quartz arenite are exposed. On the southern shore of Black Lake, about 10 m of marble breccia is exposed only 50 m from the contact with the Fishog subdomain. These marble layers probably acted as slip planes during the development of the CMBBZ, and the rocks at Bob Lake in particular indicate that the CMBBZ was not derived entirely from deformed Fishog subdomain rocks.

The CMBBZ has served as a zone of considerable pegmatite dike formation. In any outcrop, many generations of granitic pegmatites are observed in various degrees of mechanical and mineralogical disaggregation

Photo 15. Contact between straight gneiss (upper part of photo) and pure dolomite marble within the CMBBZ. Exposure is located on Haliburton County Road 2, south of Bob Lake, 1 km north of the map area. The contact between the marble and the gneiss is a 5 to 10 cm thick, calcareous, micaceous layer.

and degrees of transposition into the gneissosity. These dikes may provide a means for examining the development of the CMBBZ through precise geochronology.

The age of the CMBBZ is not well constrained. It is younger than both the Fishog subdomain and the Grenville Supergroup strata that were disrupted to form the Denna Lake Structural Complex. It was affected by the upper amphibolite facies metamorphic event that affected the Denna Lake Structural Complex at *circa* 1100 Ma. It is cut by the late granite pegmatite dikes that cut most of the Precambrian rocks in the area (*circa* 1000 Ma. It is also cut by Late Proterozoic diabase dikes (unit 33). Thus, it probably originated at about 1200 Ma, and was active to about 1050 Ma. The history of the CMBBZ between the onset of magmatism in the Fishog subdomain (*circa* 1400 Ma) and the deposition of the Grenville Supergroup strata (*circa* 1280 to 1250 Ma) is not known.

LATE TO POSTTECTONIC FELSIC INTRUSIVE ROCKS

Felsic Intrusive Rocks (unit 31)

Two bodies of weakly foliated to massive, medium- to coarse-grained monzogranite are located on and west of Haliburton County Road 2 northeast of Devil's Lake, in the north-central part of the map area. Xenoliths of mafic gneiss similar to the country rock, up to 100 cm in dimension, are present near the margins of the bodies. The monzogranite is cut by granite pegmatite dikes of unit 32. Both monzogranite bodies are located near the western margin of the CMBBZ, close to the Boshkung shear zone of Schwerdtner and Mawer (1982). It is not known if this felsic magmatism is in any way related to this structure.

In thin section, the rock is compositionally similar to some of the least deformed massive granites from within the Fishog subdomain (unit 13), although plagioclase is more abundant in the former. There is a weak fabric defined by the orientation of biotite grains in the rock (approximately 5 percent of the rock, no other mafic minerals apart from opaques) and the rock has been recrystallized to a polygonal texture.

An intrusion possibly related to the rock described above is present in the large roadcut at Miners Bay, in marble breccia of the Denna Lake Structural Complex. Here a medium-grained, weakly foliated granite locally intrudes the marble breccia, but higher in the cliff-face exposure the granite is clearly deformed with the breccia (Figure 13).

These felsic intrusive rocks are volumetrically minor within the map area, but are significant because they were emplaced late in the history of the development of the CMBBZ and the Denna Lake Structural Complex. On the basis of map distribution, crosscutting relationships, and massive nature, these felsic rocks are mainly posttectonic, but their recrystallized textures and local weak fabric indicate that they were emplaced prior to the cessation of metamorphism, and possibly deformation, in the map area. They are similar to the pegmatite dikes in the area in this regard, and are probably of roughly the same age as the dikes, i.e., about 1030 ± 20 Ma (*see* Table 15; *see also* "Geochronology"). This is also a rough estimate as to the end of deformation in the Denna Lake Structural Complex, and of the waning stages of deformation in the CMBBZ.

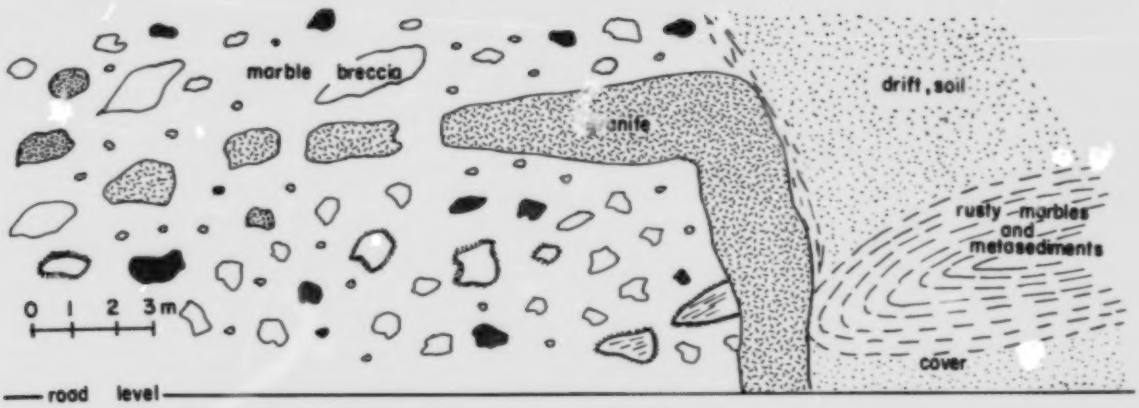


Figure 13. Contact relationships between a late tectonic monzogranite and a heterolithic marble breccia of the Denna Lake Structural Complex, Miners Bay. Sketched from a photograph.

Potassic Pegmatitic Intrusive Rocks (unit 32)

The late to posttectonic potassic intrusive rocks are composed of four main types. Undeformed syenite (unit 32b) and syenogranite (unit 32d), and cataclastic syenite (unit 32a) and syenogranite (unit 32c). All types are coarse grained, and commonly magnetite bearing. Allanite, diopside, biotite and muscovite are common accessory minerals. In some of the dikes, particularly the undeformed dikes, well-developed graphic potassium feldspar is present. No consistent trend is observed for the dikes, but north and northeast trends are commonly observed. The dikes are found in all three major tectonic zones of the Digby–Lutterworth area, but higher concentrations do occur in the Denna Lake Structural Complex. Few deformed dikes are present in the Fishog subdomain, but they are common in the Denna Lake Structural Complex. A variety of deformed and undeformed pegmatite dikes are present in the CMBBZ, but it is difficult to ascertain if the intensely deformed pegmatite dikes in the CMBBZ are indeed of the same age as those in the Denna Lake Structural Complex. The undeformed dikes in all three main tectonic zones appear to be roughly equivalent in age. If the late, undeformed pegmatite dikes in the Digby–Lutterworth area are roughly the same age as pegmatites elsewhere in the Grenville Province, they were emplaced at about 1030 ± 20 Ma (*see* Table 13; *see also* "Geochronology"). This age would date the end of deformation in the Denna Lake Structural Complex, and the waning stages of deformation in the CMBBZ.

Within the Denna Lake Structural Complex, there is a spatial association between the pegmatite dikes and some of the granitic rocks, and, in places, the two are intergradational. This is particularly true for the older, deformed pegmatite dikes. These granitic rocks have for the most part been mapped as part of the pegmatites in the area (unit 32), but it is possible that some small granitic bodies of unit 31 may have been grouped with these rocks. The intergradational nature of the granites and the pegmatites may be due to the development of chill margins on some of the larger dikes and intrusions; alternatively, it may indicate that some of the earlier, now deformed pegmatites are genetically related to the granitoid rocks. This was apparently the case with late tectonic granodiorite to monzogranite plutons intruded into the Grenville Supergroup in the adjacent Howland area (Easton 1983, 1987a). It would appear likely that a number of periods of pegmatite dike injection have occurred in the map area, but so far it has not been possible to systematically discriminate ages of pegmatite dikes in the area other than on an individual outcrop basis. This is due mainly to the chemical and lithologic similarity of the dikes.

Cerny (1982) and Ginsburg et al. (1979) classify pegmatites on the basis of depth of emplacement, type of mineralization and metamorphic environment (Table 10). Pegmatites in the Digby–Lutterworth area, particularly those in the Denna Lake Structural Complex and parts of the CMBBZ, belong to class III, having been emplaced at depths of 7 to 11 km, hosted in amphibolite facies metamorphic rocks, and containing minimal mineralization. Late pegmatites in the CMBBZ and the Fishog subdomain are also of class III, although some pegmatites in the CMBBZ have the characteristics of class IV pegmatites. Note that the depth of emplacement in the classification scheme given in Table 10 is based on geobarometric considerations related to the enclosing metamorphic grade, and does not directly relate to the distance of the pegmatites from the paleosurface.

A few white pegmatite dikes do occur in the northeastern part of the Denna Lake Structural Complex, and are abundant northeast of the map area in the same zone. These dikes are composed mainly of plagioclase feldspar, white potassium feldspar and quartz, with less than 5 percent mafic minerals, either biotite or diopside. They are roughly monzonites to syenites in bulk rock composition. These dikes are rich in zirconium, and adjacent clastic metasedimentary rocks commonly also have high niobium, yttrium and zirconium contents compared to other clastic metasedimentary rocks from

TABLE 10. CLASSIFICATION OF PEGMATITE DIKES (AFTER CERNY 1982 AND GINSBURG et al. 1979). DIKES IN THE DIGBY-LUTTERWORTH AREA BELONG MAINLY TO CLASS III.

I. Pegmatite formation at shallow depths (1.5 to 3.5 km). Miarolitic pegmatites – pods of pegmatite in the upper parts of epizonal granites intrusive into rocks of the lowest metamorphic grades, with cavities carrying piezoelectric quartz, optical-grade fluorite, gem-quality beryl, topaz, etc.

II. Pegmatite formation at intermediate depths (3.5 to 7 km). Rare-element pegmatites – pegmatites with Li, Rb, Cs, Be, Ta, (Sn, Nb) mineralization, filling fractures in rocks of lower to middle amphibolite facies, and generated by the fractionation of differentiated allochthonous granites.

III. Pegmatite formation at great depths (7 to 11 km). Mica-bearing pegmatites – hosted by metamorphic rocks of upper amphibolite facies, and carrying minimal rare-element mineralization, if any, but commonly extensive mica reserves. Direct products of anatexis or separated from anatectic, more or less autochthonous granites.

IV. Pegmatite formation at maximal depths (>11 km). In granulite facies terranes, usually with no economic mineralization but locally containing allanite, monazite and corundum. They commonly grade into migmatites, having no obvious granitic parents.

TABLE 11. CHEMICAL ANALYSES OF MIDDLE TO LATE PROTEROZOIC INTRUSIVE ROCKS, DIGBY-LUTTERWORTH AREA.

(wt. %)	1	2	3	4	5
SiO_2	60.2	53.2	52.7	65.1	50.50
TiO_2	2.22	2.03	2.05	0.26	2.47
Al_2O_3	12.6	14.6	14.6	17.5	15.10
Fe_2O_3	1.75	3.83	4.09	1.07	5.40
FeO	3.20	7.13	6.18	0.95	4.50
MgO	3.50	3.84	5.26	0.35	4.90
CaO	2.51	7.95	7.41	1.75	5.54
Na_2O	0.33	3.97	3.75	5.17	4.10
K_2O	10.1	0.65	1.40	6.76	3.76
P_2O_5	0.89	0.15	0.29	0.00	0.95
MnO	0.05	0.13	0.14	0.04	0.14
CO_2	0.44	0.62	0.56	0.47	0.20
H_2O^+	0.26	0.27	0.10	0.15	0.90
H_2O^-	0.07	0.16	0.07	0.08	—
total	98.3	98.7	99.5	99.8	98.46
(ppm)					
Ba	5710	360	920	580	
Be	11	1	2	2	
Co	16	32	33	—	
Cr	135	70	159	—	
Cu	—	16	37	6	
Li	20	16	8	6	
Nb	30	18	30	15	
Ni	96	43	79	—	
Pb	27	—	—	19	
Rb	150	15	27	145	
Sc	9	20	19	—	
Sr	820	580	950	420	
Th	8	—	—	10	
V	85	155	155	6	
Y	13	25	25	40	
Zn	117	155	126	42	
Zr	315	30	55	660	

Notes:

1: 84-RME-0079A, unit 34, Highway 35, 8.5 km north of Norland, trachyandesite

2: 84-RME-0058A, unit 33, Highway 35, 17 km north of Norland, alkaline basalt

3: 84-RME-0079C, unit 33, Highway 35, 8.5 km north of Norland, alkaline basalt

4: 84-RME-0284A, unit 32, Highway 121 south, 2 km east of Highway 35, white-pegmatite

5: Cambro-Proterozoic trachyandesite flow, Buckingham, Quebec; Analysis 3, Table 2, Lafleur and Hogarth 1981

—: not detected

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto, unless otherwise indicated.

the Denna Lake Structural Complex (Easton 1987b). The results of an analysis of one of these pegmatites taken from a roadcut off Highway 121 south, about 4 km northeast of the northeastern corner of the map area, is given in Table 11, analysis 4. The greater abundance of these more mineralized dikes to the north may reflect a north to south metamorphic gradient in the map area, on the basis of the Cerny-Ginsburg pegmatite classification scheme (Table 10). Alternatively, these pegmatites may be farther from their anatectic source region than would be expected from the Cerny-Ginsburg scheme.

LATE PROTEROZOIC

LATE TO POSTTECTONIC MAFIC INTRUSIVE ROCKS (UNIT 33)

Two slightly metamorphosed, fine-grained diabase dikes are present in the Digby-Lutterworth area. Both are exposed on the west side of Highway 35 in the CMBBZ: one is located 1.5 km south of Moore Falls and is adjacent to an unmetamorphosed trachyandesite dike; the second is located approximately 3.5 km north of Miners Bay. Both rocks are dark grey to dark green, fine grained, and have a slight to nonexistent chill margin. They have been recrystallized to a polygonal texture, but do not show a strong fabric development. The dikes commonly follow gneissic layering in the host rocks, changing layers at a high angle to gneissosity. In thin section, the two rocks differ only slightly and then mainly in fabric development. Sample 84-RME-0058A from the northern locality consists of roughly equal proportions of chlorite, hornblende, and relict clinopyroxene and andesine (An_{50}). The rock has been recrystallized, is roughly equigranular, but shows no preferred fabric. Sample 84-RME-0079C, from the southern locality, shows a weak to moderate foliation, contains biotite and chlorite, and relict clinopyroxene present only as 2 to 3 mm-sized phenocrysts. The feldspar composition is more sodic, at An_{40}, than that of the northern occurrence. The average grain size in both samples is about 1 mm. The results of analyses of both samples are given in Table 11, analyses 2 and 3. The results are very similar, and confirm field work suggesting that the two dikes are similar in relative age. The rock type is best classed as an alkalic basalt, but near the subalkalic-alkalic dividing line.

The better developed fabric in the more southerly sample may indicate that the two dikes were injected into the CMBBZ at slightly different times, the more southerly sample intruded before deformation in the CMBBZ had ceased and therefore slightly older. Alternatively, the two samples may have been injected at the same time, but the southern sample may have been injected at a slightly deeper crustal level, and subjected to a slightly different stress regime than the northern sample. Certainly, emplacement occurred before the end of regional metamorphism, which is dated at roughly 1000 Ma in the region (Berger and York 1981; *see* "Geochronology"). As few chemical analyses of diabase dikes in the Central Metasedimentary Belt are present in the literature, it could not be determined if these dikes are chemically unusual in any way, or if they are typical of the late diabase dikes in the region.

POSTTECTONIC INTERMEDIATE TO FELSIC ALKALIC INTRUSIVE ROCKS (UNIT 34)

On the east side of Highway 35, 1.5 km south of Moore Falls (directly across the highway from the southern occurrence of unit 33 discussed above), an undeformed, unmetamorphosed, fine-grained dike rock cuts gneissosity in gneisses of the CMBBZ (Photo 16). The rock is a leucocratic to mesocratic, pinkish to purplish weathering, biotite-bearing, intermediate to felsic rock which has a weak trachytic texture and a poorly developed chill margin. The dike varies in width from 20 to 100 cm, and locally engulfs large rafts of county rock (Photo 16). In thin section, this rock is fresh, weakly trachytic, and consists of about 25 to 30 percent biotite as 1 to 1.5 mm microphenocrysts and 4 mm phenocrysts; 65 percent andesine feldspar, which has been partly altered to clay minerals; 5 percent opaque minerals; and about 1 percent apatite. The grain size of the groundmass is 0.25 to 0.5 mm and it consists of biotite, feldspar, opaque minerals and apatite. The results of a chemical analysis of this rock is given in Table 11, analysis 1. The alkalic character of this rock is indicated by the high K_2O content, as well as by the high P_2O_5, CO_2, Ba, Rb, Sr and Zr contents. The rock is probably best termed a trachyandesite or an alkalic diorite. The closest analog to this rock elsewhere in the Central Metasedimentary Belt in southern Ontario and western Quebec may be a trachybasalt to trachyandesite flow, described by Lafleur and Hogarth (1981) from Buckingham, Quebec (Table 11, analysis 5). Although lower in silica than analysis 1, it also has the high P_2O_5 and CO_2 contents, and similar values for TiO_2. Although K_2O is given as 3.76 weight percent in the analysis, Lafleur and Hogarth reported a range of K_2O values in the samples from 2.42 to 10.75 percent, averaging 6.7 percent. Lafleur and Hogarth (1981) also reported a K-Ar age of 573 ± 32 Ma for this flow, making this rock early Cambrian or very Late Proterozoic in age. Easton and Roddick (1988) subsequently dated biotite and whole-rock samples of this dike using the K-Ar dating method, and achieved ages of 898 ± 17 Ma and 902 ± 12 Ma, respectively. Although excess argon is present within the CMBBZ (Easton and Roddick 1988) in the Minden area, there is no indication of excess argon in the analyzed samples, and the close agreement of the two ages suggests that 900 Ma is a reasonable approximation for the age of the dike in the Digby–Lutterworth area.

The dike in the map area is located in the CMBBZ, and as the trachyandesite flow in the Buckingham, Quebec, area is related to the development of the Ottawa–Bonnechere graben system, crustal weaknesses associated with the CMBBZ may have served to localize some trachyandesite magma in this part of the Grenville Province. If related to the graben system, this occur-

Photo 16. Cambro–Proterozoic trachyandesite dike cutting gneiss of the CMBBZ on the eastern side of Highway 35, 1 km south of Moore Falls. Note large block of gneiss engulfed by the dike in the centre of the photo.

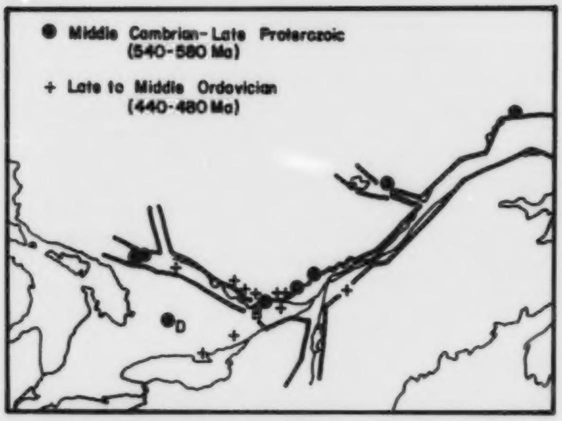

● Middle Cambrian–Late Proterozoic (540-580 Ma)
+ Late to Middle Ordovician (440-480 Ma)
D

Figure 14. Distribution of Middle Cambrian–Late Proterozoic (540 to 580 Ma) and Late to Middle Ordovician (440 to 480 Ma) magmatic alkalic rocks in south-central Canada, and the relationship of these rocks to the Ottawa–Bonnechere rift system. (B = Buckingham, Quebec; D = Digby area trachyandesite dike)

rence is much farther east and south than other known occurrences of rocks of this age in central Canada (Figure 14).

PALEOZOIC

MIDDLE ORDOVICIAN

Basal Group

SHADOW LAKE FORMATION (UNIT 35a)

Paleozoic strata outcrop in the southern part of the map area (*see* Figure 4). The lowermost beds rest on gneisses of the Fishog subdomain, the CMBBZ and the Glamorgan Gneiss Complex, as well as on marble breccia of the Denna Lake Structural Complex. The lowermost beds consist of 50 to 150 cm of greenish grey, coarse calcareous arkose overlain by up to 2.3 m of thinly laminated red and green shales in the proportion of about 60:40 red to green shale. The Shadow Lake Formation is only well exposed in the map area on lot 23, concession 1, Digby Township, in a roadcut on the western shore of Digby Lake, and in a small quarry on lots 7 and 8, concession 1, Digby Township, northeast of Oak Lake. Elsewhere, the Shadow Lake Formation is covered in talus from the upper portion of the 10 to 15 m high scarp that marks the Paleozoic–Precambrian contact over most of the map area. The unconformity with the Precambrian rocks is not exposed in the map area, although at the quarry northeast of Oak Lake, it is only about 25 to 50 cm beneath the lowermost exposed beds. These siliceous clastic sedimentary rocks are assigned to the Shadow Lake Formation of probable Middle Ordovician age, as defined by Liberty (1969, p.10; *see* Table 12, *this report*). The results of chemical analysis on representative samples of the Shadow Lake Formation collected from the quarry northeast of Oak Lake are given as analyses 1, 2 and 3, Table 13.

Simcoe Group

GULL RIVER FORMATION (UNIT 35b)

Limestone and shale of the lower and middle members of the Gull River Formation, Simcoe Group, overlie the Shadow Lake Formation in the map area, and are essentially flat lying, with dips of 2 to 5° but of varied strike. The exposures of the Gull River Formation in the map area are located 10 to 20 km northwest of the type section for the Gull River Formation on Highway 35, 6.5 km north of the town of Coboconk (Liberty 1969). The lower member of the Gull River Formation can be divided into four submembers (Liberty 1969), all of which are present in the map area. These submembers are best exposed in the Oak Lake roadcut on lot 10, con-

TABLE 12. COMPARISON OF CHRONO–, BIO– AND LITHOSTRATIGRAPHIC TERMS IN THE BASAL AND SIMCOE GROUP ROCKS OF MIDDLE ORDOVICIAN AGE, ONTARIO, AFTER LIBERTY 1969, p.10.

CHRONOSTRATIGRAPHIC TERMS	BIOSTRATIGRAPHIC TERMS	LITHOSTRATIGRAPHIC TERMS	
TRENTONIAN	COBOURG	SIMCOE GROUP	LINDSAY
	SHERMAN FALL		VERULAM
	HULL-KIRKFIELD		BOBCAYGEON
	ROCKLAND		
BLACKRIVERIAN	LERAY		GULL RIVER
	LOWVILLE		
	PAMELIA	BASAL GROUP	SHADOW LAKE
UNDERLYING ROCKS			UPPER CAMBRIAN

TABLE 13. CHEMICAL ANALYSES OF SHALES AND ARKOSES FROM THE SHADOW LAKE FORMATION, DIGBY–LUTTERWORTH AREA AND FROM THE GULL RIVER FORMATION.

	Shadow Lake Formation			Gull River Formation					
(wt. %)	1	2	3	4	5	6	7	8	9
SiO_2	63.4	71.0	87.8	1.28	2.36	1.58	3.88	1.32	1.54
TiO_2	0.70	0.54	0.20	NR	NR	NR	NR	NR	NR
Al_2O_3	16.2	13.3	3.52	0.31	1.09	0.33	1.72	0.33	0.55
Fe_2O_3	4.68	3.20	2.18	0.33	0.71	0.19	0.50	0.23	0.33
FeO	0.80	0.51	0.29	NR	NR	NR	NR	NR	NR
MgO	2.34	1.48	0.41	1.43	3.01	2.39	13.19	0.67	0.35
CaO	0.52	0.48	1.69	53.26	49.98	51.64	36.85	54.12	53.56
Na_2O	0.78	0.99	0.30	NR	NR	NR	NR	NR	NR
K_2O	6.46	5.56	1.21	NR	NR	NR	NR	NR	NR
MnO	0.03	0.02	0.02	NR	NR	NR	NR	NR	NR
CO_2	0.24	0.19	1.09	NR	NR	NR	NR	NR	NR
S	0.0	0.01	0.01	0.02	trace	0.06	0.06	0.07	0.02
H_2O^+	3.18	1.66	0.57	NR	NR	NR	NR	NR	NR
H_2O^-	0.07	0.52	0.09	NR	NR	NR	NR	NR	NR
total	99.4	99.5	99.6	100.01	99.70	99.32	99.49	99.94	98.81
(ppm)									
Ba	770	950	240						
Co	12	7	--						
Cr	59	41	9						
Co	7	6	--						
Li	20	13	14						
Nb	12	10	8						
Ni	20	19	--						
Pb	--	10	--						
Rb	180	125	20						
Sc	6	5	3						
Sr	145	250	185						
V	70	55	55						
Y	7	13	25						
Zn	52	43	9						
Zr	95	150	125						

Notes:

1: 84-RME-0308A, red shale, lot 7-8, Conc. 1, Digby Tp.
2: 84-RME-0308B, green shale, lot 7-8, Conc. 1, Digby Tp.
3: 84-RME-0308C, green arkose, lot 7-8, Conc. 1, Digby Tp.
4: Gull River Fm., Lower Member (A1), Burnt River quarry, Somerville Tp., lot 13, Conc. 4, reported in Goudge 1938
5: Gull River Fm., Lower Member (A2), Burnt River quarry, Somerville Tp., lot 13, Conc. 4, reported in Goudge 1938
6: Gull River Fm., Lower Member (A3), Coldwell Medonte quarry, Simcoe, Medonte, lot 19-20, Conc. 8, reported in Goudge 1938
7: Gull River Fm., Lower member (A4), Coldwater Medonte quarry, Medonte, lot 19-20, Conc. 8, reported in Goudge 1938
8: Gull River Fm., Middle Member (B), Coldwater Medonte quarry, Medonte, lot 19-20, Conc. 8, reported in Goudge 1938
9: Gull River Fm., Upper Member (B3), Coboconk quarry, Somerville Tp., lot 37, Front, reported in Goudge 1938
--: not detected
NR: not reported

Analyses by Geoscience Laboratories Section, Ontario Geological Survey, Toronto.

cession 9, Laxton Township, 500 m south of the map area and at the roadcut on the western side of Head Lake.

The lower submember ("A1" of Liberty 1969) consists of about 2.4 m of buff-weathering, pale greenish grey, pinkish grey and grey, fine-grained dolomitic limestone in beds ranging in thickness from 2 to 35 cm. This unit has a conchoidal fracture, contains quartz grains throughout, and contains vugs lined with calcite. The unit consists of dolostone, calcareous dolostone and dolomitic limestone. The proportion of dolomitic limestone decreases upsection.

The lower lithographic (micritic) submember ("A2" of Liberty 1969) consists of about 2 m of grey-weathering, chocolate brown and grey, lithographic limestone in beds 20 to 30 cm thick.

The mottled carbonate submember ("A3" of Liberty 1969) consists of about 2.5 m of grey, fine-grained dolomitic limestone with digitate, brown, lithographic limestone. The beds range from 2 to 5 cm in thickness.

The upper submember ("A4" of Liberty 1969) consists of 2 m of buff-weathering, pale green and greenish grey, fine-grained dolomite in beds up to 50 cm thick. Fossils from the lower member of the Gull River Formation include bryozoa and ostracods and suggest a Pamelia age (Table 12).

The middle member of the Gull River Formation is only exposed in the extreme southernmost part of the map area, and exposures are poor. It is well exposed in roadcuts on Highway 503 near Head Lake, and on lot 10, concession 9, Laxton Township, about 500 m south of the map area.

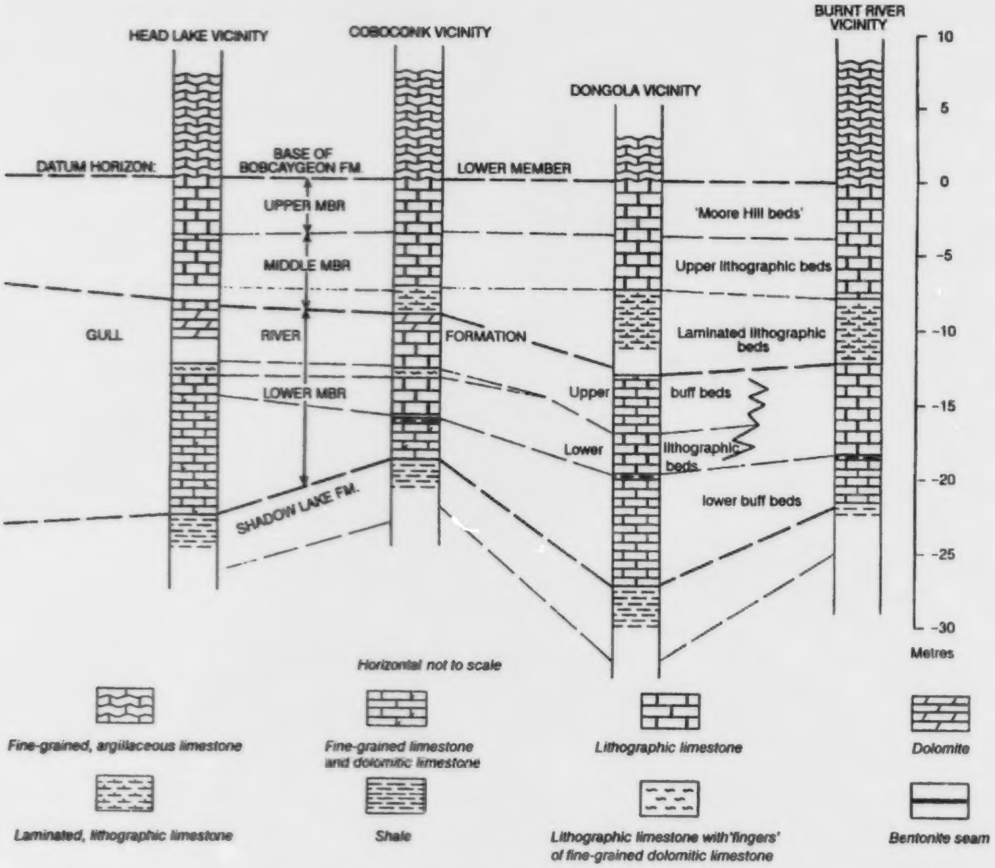

HEAD LAKE VICINITY
COBOCONK VICINITY
DONGOLA VICINITY
BURNT RIVER VICINITY
DATUM HORIZON:
BASE OF BOBCAYGEON FM.
LOWER MEMBER
UPPER MBR
MIDDLE MBR
GULL
RIVER
FORMATION
LOWER MBR
SHADOW LAKE FM.
'Moore Hill beds'
Upper lithographic beds
Laminated lithographic beds
Upper
buff beds
Lower
lithographic beds
lower buff beds
10
5
0
-5
-10
-15
-20
-25
-30
Metres
Horizontal not to scale
Fine-grained, argillaceous limestone
Fine-grained limestone and dolomitic limestone
Lithographic limestone
Dolomite
Laminated, lithographic limestone
Shale
Lithographic limestone with 'fingers' of fine-grained dolomitic limestone
Bentonite seam

Figure 15. Regional facies chart of the Shadow Lake and Gull River formations based on local composite sections, Digby–Lutterworth area and vicinity. Head Lake area section is based on localities listed in Table 12; Coboconk area is located 15 km south-southeast of the map area and is the type section for the Gull River Formation; Dongola area is located 1 km south of the southeast corner of the map area on Highway 503. The Burnt River area is located about 25 km southeast of the map area, in Somerville Township. Adapted from Figure 4, Liberty 1969 (p.35).

The middle member of the Gull River Formation consists of about 4.5 m of thinly laminated, grey, lithographic limestone with thin, green argillaceous partings between the beds. About 1 m of nonlaminated, grey lithographic limestone appears in the middle of the unit. Pelecypods, trilobites and ostracods have been reported from these beds (Liberty 1969). The upper part of the middle member includes grey-weathering, grey and cream lithographic limestone with pinkish mottling.

Figure 15 is a compilation chart for the Shadow Lake and Gull River formations in and adjacent to the map area, made by Liberty (1969). Table 14 is a composite section for the southern part of the map area, modified from Liberty (1969, p.125-126). Liberty (1969) concluded that the abundance of lithographic limestone in the Gull River Formation indicated deposition under shallow water lagoonal conditions.

The Al, A2, A3 and A4 submembers of the lower member of the Gull River Formation have been quarried in the past, mainly for crushed and building stone (Liberty 1969). The dolomitic limestones of the lower member of the Gull River Formation may also be of use for industrial purposes (*see* Springer 1983).

CENOZOIC

QUATERNARY

Pleistocene and Recent

The bulk of the Cenozoic sedimentary rocks in the map area were deposited during the Pleistocene epoch. The distribution of these units is shown in Figure 16. Most of the Pleistocene deposits are sands, gravels and silts distributed along the Gull River valley. These deposits extend south into the Fenelon Falls area where Finamore and Bajc (1983) have mapped them as shallow water glaciolacustrine deposits related to the Fenelon Falls outlet of former glacial Lake Algonquin. The sand and gravel deposits are well sorted, and have probably been in part reworked by the ancestral Gull River. Several small sand and gravel quarries have, and are currently

TABLE 14. COMPOSITE SECTION OF SIMCOE AND BASAL GROUP STRATA, HEAD LAKE AREA, LAXTON TOWNSHIP, VICTORIA COUNTY. BASED ON DATA FROM LIBERTY (1969) AND PRESENT GEOLOGICAL SURVEY, DIGBY–LUTTERWORTH AREA.
Sections from Head Lake east hill (lots 8 and 9, conc. 6, Laxton Tp.); Schoolhouse hill section (lot 9, conc. 6, Laxton Tp.); Head Lake west section (lot 23, conc. 1, Digby Tp.), Oak Lake south road cut (lot 10, conc. 9, Laxton Tp.), and Oak Lake north section (lots 7 and 8, conc. 1, Digby Tp.).

Thickness (m)	
	TOP OF SECTION **BOBCAYGEON FORMATION, LOWER MEMBER (C1)** **(not exposed in map area)**
7.0	Limestone: grey, fine grained, argillaceous; weathers steel blue and grey, into thin rubbly beds and massive beds; great profusion of *Lyopora (Columnaria) halli* in lowermost strata
	GULL RIVER FORMATION, UPPER MEMBER **(not exposed in map area)**
3.8	Limestone: grey, sublithographic and lithographic; weathers grey and into massive beds; black nodular chert present in fair abundance; profusion of *Tetradium cellulosum* and *T. fibratum* (B_3)
	GULL RIVER FORMATION, MIDDLE MEMBER
3.4	Limestone: brown grey and cream, lithographic, with 'eyes' of crystalline calcite; weathers grey and into massive beds (B_2)
1.2	Concealed
	GULL RIVER FORMATION, LOWER MEMBER
1.5	Limestone: magnesian, grey and greenish grey, fine to medium grained; weathers buff and into 8 to 10 inch thick beds; styolites present (A_4)
1.8	Concealed
0.8	Limestone: grey and brown, lithographic with 'fingers' of brown, fine–grained, argillaceous, magnesian limestone (A_3)
1.2	Limestone: grey and brown, lithographic; weathers grey and into massive beds (A_2)
7.9	Limestone: grey and greenish grey, fine grained and magnesian; weathers buff and greenish grey, and into 4 to 8 inch thick beds; fracture is conchoidal and vugs are filled with calcite and gypsum crystals (A_1)
	SHADOW LAKE FORMATION
2.4	Shale: about 60% red shale, remainder green or greenish grey, locally some arkose, characterized by large subangular quartz grains and greenish to pinkish colour, lies below the shale; finely laminated; thickness of unit is somewhat variable, but exposure is commonly poor
	BASE OF SECTION

Note: Presence of persistent clay seams ('bentonite') was not noted in any of the sections due to the quality of the exposures.

operating on these deposits. These quarries are located mainly along Highway 35, between Moore Falls and Norland (Figure 16). These deposits have not been fully exploited, and are a future resource in the area.

Till cover is thin over most of the area, and consists of a thin boulder till over bedrock, and rarely is the till thick enough to subdue bedrock topography. Much of the central and northern part of the Fishog subdomain is barren outcrop. Overburden (till and soil) is thicker in the area underlain by the Denna Lake Structural Complex, probably due in part to weathering of the marbles. In addition, material may have been stripped from this area during the time the Gull River spillway was in existence.

Several areas of thick till do occur in the map area, principally along the western side of Gull Lake and along the Gull River valley (Figure 16), as well as in the northern part of the map area. Drift is sufficiently thick in these areas to subdue bedrock topography, and consists of a silty till with numerous large angular boulders. Henderson (1973) suggested that similar deposits near Haliburton (northeast of the map area) indicated a pause in the rate of ice retreat in the area, or a readvance. A second type of till occurs in the southern part

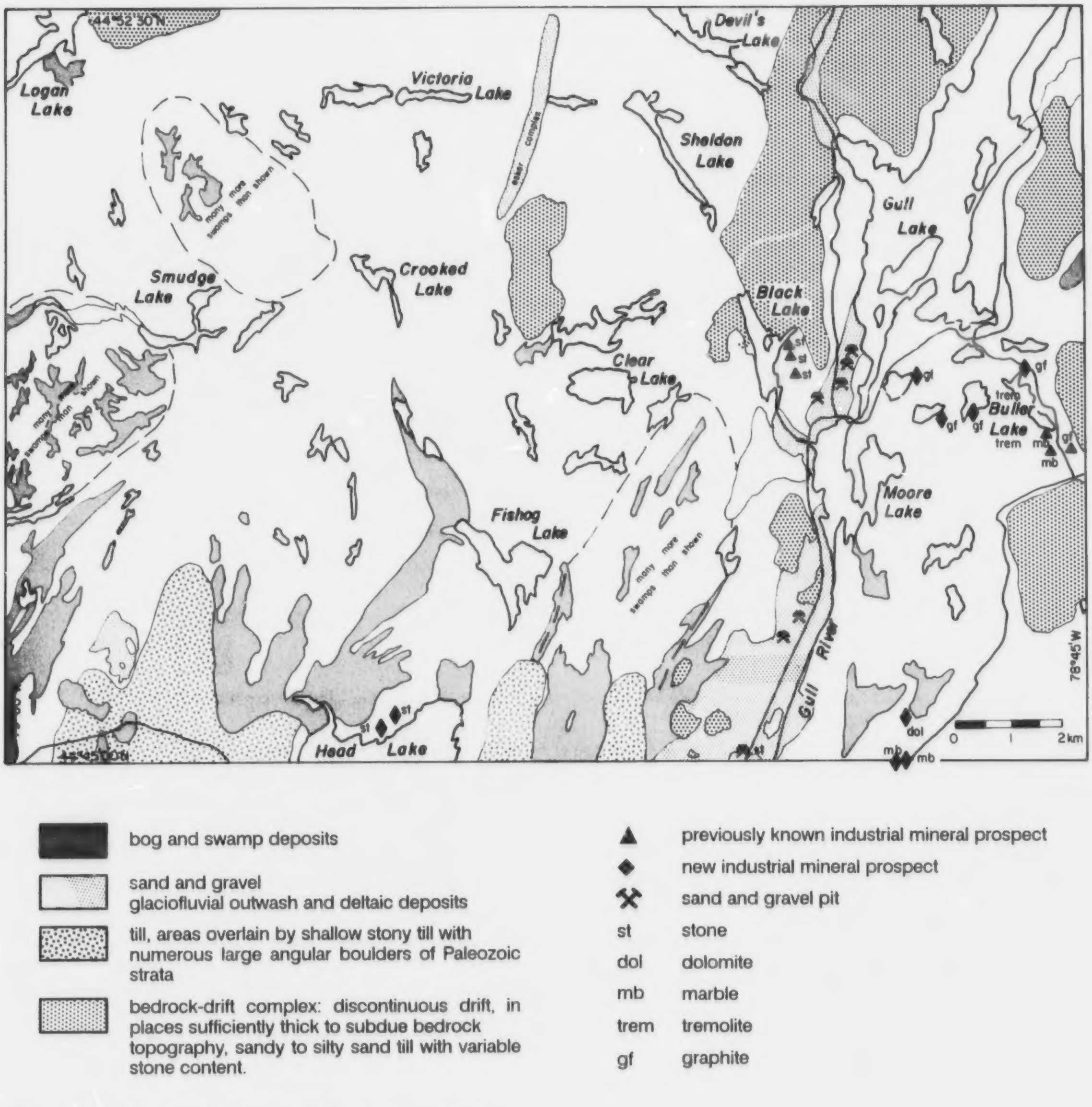

44°52'30"N
Logan Lake
Victoria Lake
esker complex
Devil's Lake
Sheldon Lake
many more swamps than shown
Gull Lake
Smudge Lake
Crooked Lake
Black Lake
st
Clear Lake
gf
trem
Buller Lake
mb
Moore Lake
Fishog Lake
Gull River
78°45'W
0 1 2km
dol
Head Lake
44°45'00"N
▬ bog and swamp deposits
▨ sand and gravel glaciofluvial outwash and deltaic deposits
▨ till, areas overlain by shallow stony till with numerous large angular boulders of Paleozoic strata
▨ bedrock-drift complex: discontinuous drift, in places sufficiently thick to subdue bedrock topography, sandy to silty sand till with variable stone content.
▲ previously known industrial mineral prospect
◆ new industrial mineral prospect
⚒ sand and gravel pit
st stone
dol dolomite
mb marble
trem tremolite
gf graphite

Figure 16. Surficial geology of the Digby–Lutterworth area.

of the map area and overlies Paleozoic strata in the Head Lake area. It consists mostly of a silty till containing large angular boulders of Paleozoic rocks. These boulders occur only in till deposited at or near the Precambrian–Paleozoic unconformity. Since ice flow directions in the area trend at 200° (Henderson 1973; and measurements by field party personnel), these tills must be of very local derivation because of the high proportion of Paleozoic boulders.

An esker or drumlin complex is located 2 km east of Victoria Lake, and has a length of about 4 km, a width of 300 m, and trends at roughly 198°. Its isolated occurrence may indicate that it is an esker rather than a drumlin. No sections are exposed through the ridge.

The recent deposits in the map area are composed of organic swamp and alluvial deposits. They occur in two settings: broad swamps located along the Paleozoic–Precambrian unconformity; and linear swamps occupying low-lying areas parallel to regional foliation and gneissosity. Recent alluvial deposits are associated with the Gull River system and include minor stream sediments and reworked glaciolacustrine sands and gravels.

Metamorphism

Metamorphic conditions in the area are difficult to establish, because of the absence of rocks with diagnostic mineral assemblages. Where present, marbles in the area are in general too pure, and siliceous clastic metasedimentary rocks are not sufficiently aluminous, to produce key, diagnostic mineral assemblages. Metamorphic grade in the area related to peak regional metamorphism in the Central Metasedimentary Belt at *circa* 1100 Ma (Table 15) is estimated to be medium grade metamorphism (*see* Figure 2). In places in the Denna Lake Structural Complex, sufficient data are available to place metamorphism at the upper amphibolite facies. Within the Fishog subdomain, more than one period of metamorphism may be present. Metamorphic conditions within the four major tectonic zones of the map area are outlined below.

METAMORPHISM IN THE DENNA LAKE STRUCTURAL COMPLEX AND GLAMORGAN GNEISS COMPLEX

The main constraints on metamorphic conditions in the area underlain by the Denna Lake Structural Complex are based on mineral assemblages present within the marbles of the complex. At Buller Lake, the assemblage dolomite + quartz + diopside + calcite + tremolite is present. This assemblage occurs at 5 kilobars and $\chi CO_2 = 0.95$ at 600°C (Winkler 1979). The absence of forsterite in marbles in the area indicates temperatures of less than 650°C, and pressures of 3 to 5 kilobars (Winkler 1979).

Aluminous metasedimentary rocks in the map area are sillimanite-bearing, and are generally found in association with muscovite, indicating metamorphic conditions of 3 to 5 kilobars and temperatures of 550 to 650°C, in agreement with the estimates obtained from the marbles. The presence of granitic pods representing the first stage of anatexis in some of the clastic metasedimentary rocks in the southeastern part of the complex indicates temperatures of 600 to 650°C. Thus, for the Denna Lake Structural Complex, a pressure of 5 kilobars and 600°C is a reasonable estimate for peak metamorphic conditions at *circa* 1100 Ma.

It should be noted that metamorphism occurred after the development of the marble breccia, or at least during its formation, as clasts within the breccia have reacted with the carbonate host to form a variety of metamorphic minerals. This is an important constraint on the timing of the formation of the Denna Lake Structural Complex, and indicates formation between 1100 Ma (peak regional metamorphism) and 1000 Ma (late, undeformed pegmatite dikes) (Table 15).

Chesworth (1971) estimated the metamorphic conditions in the Bark Lake–Salerno Lake area, 25 km east of the map area, at 3.5 to 5.5 kilobars and 550 to 650°C when replotted on modern petrogenetic grids (e.g., Winkler 1979). Also, in the Bark Lake area, Berger and York (1981) estimated argon-blocking temperatures for hornblende from the Bark Lake diorite to be about 600 to 700°C at 1000 Ma. This value is in agreement with Chesworth's (1971) estimates based on mineral paragenesis.

Metamorphic conditions are more difficult to establish for the Glamorgan Gneiss Complex, and it is difficult to determine whether more than one metamorphic event has affected the complex. The Denna Lake Structural Complex and the area from which Chesworth (1971) obtained his estimates lie on both sides of the Glamorgan Gneiss Complex; therefore, regional metamorphic conditions at *circa* 1100 Ma across the complex were probably also at about 5 kilobars and 600°C.

METAMORPHISM IN THE FISHOG SUBDOMAIN

As outlined in Table 15 and in the section "Geochronology", most of the igneous activity that occurred in the Fishog subdomain took place between 1400 and 1500 Ma. Farther to the west in the Parry Sound region, at least two metamorphic events occurred in the Central Gneiss Belt: an event which resulted in granulite facies metamorphism at *circa* 1240 to 1260 Ma; and a second metamorphic event at *circa* 1100 to 1200 Ma which was roughly coincident with the main regional metamorphic event in the Central Metasedimentary Belt. Final cooling below argon-blocking temperatures in hornblende and biotite occurred at *circa* 1000 Ma, as did injection of the granite pegmatite dikes. Thus, indications of at least two periods of metamorphism are present in the Fishog subdomain, and a third is present in the country rocks to the monzonite and granite suite plutons that were emplaced at roughly 1400 to 1450 Ma.

Evidence of the existence of an older period of metamorphism associated with emplacement of the plutons of the monzonite and granite suites, and possibly older, is found in several areas. Tonalitic migmatitic gneisses of unit 1 have a definite leucosomal phase that is cut by plutonic rocks of the granite suite (units 12 to 14). This leucosome may be related to the partial melting of these rocks at the time the granite plutons were emplaced, or an early metamorphic event prior to granite emplacement. Certainly, the sill-like intrusive pattern of the granite suite rocks indicates that the tonalitic migmatitic gneiss had a well-developed layering prior to granite emplacement. The monzonite suite plutons (unit 10) have large migmatite zones developed along their margins. These zones consist of partly assimilated gneisses and migmatitic rocks. These zones appear to be related exclusively to the emplacement of the monzonite suite plutons. They indicate that metamorphic conditions of medium-grade hornfels were present around the margins of these plutons, if not of regional extent.

Migmatitic rocks are also found adjacent to rocks of the anorthosite suite (unit 5), and also indicate a local contact aureole of medium-grade hornfels, if not a regional metamorphic event at this time. Certainly, within the Fishog subdomain, metamorphism did occur at *circa* 1400 to 1450 Ma, whether it be contact or regional metamorphism.

It is difficult to determine if the 1240 to 1260 Ma metamorphic event recognized in the Parry Sound area also affected the Fishog subdomain. Granulite facies rocks have not been found in the Fishog subdomain. Pyroxene has not been observed in thin section from any granitoid rocks in the area. In addition, granulite facies rocks in the Muskoka domain are characterized by a patchy, olive-green or yellow-green colour, and can be easily recognized in the field. No olive-green or yellow-green rocks were observed in the area, and it is unlikely that any large areas of granulite facies rocks are present in the Fishog subdomain. In the absence of any granulite facies rocks, it is difficult to say if this metamorphic event is represented in the Fishog subdomain. On regional grounds, it probably is present but it is not distinctive in the field.

The regional metamorphic event at *circa* 1100 Ma also affected the Fishog subdomain as well as areas to the east and west. Major fabric development in the granite and monzonite suite rocks may have occurred at this time. Certainly these rocks were ductile at this time, as structures in the Fishog subdomain are deflected, without cataclasis, to parallelism with the CMBBZ as it is approached.

METAMORPHISM IN THE CENTRAL METASEDIMENTARY BELT BOUNDARY ZONE

As is the case with the Fishog subdomain, the CMBBZ may have been subjected to several periods of metamorphism, culminating in the *circa* 1100 Ma metamorphic event that characterizes the Grenville Province. However, the history of this zone is not well known. Locally, it includes rocks lithologically similar to those present in the Fishog subdomain, indicating that it formed sometime after 1400 Ma. Metamorphosed diabase dikes within the zone indicate tectonic movement, and that metamorphism had all but ceased by about 1000 to 900 Ma. This zone has certainly served as a zone for fluid movement, and the abundance of pegmatite dikes at all stages of disruption in this zone indicate that it was subjected to elevated temperatures for a considerable amount of time. Some of the oldest disrupted pegmatites are probably of local anatectic origin, and some potassium feldspar augen in porphyroclastic gneisses of the CMBBZ are probably porphyroblasts and are indicative of temperatures in the 650 to 700°C range. To a certain extent, it is not relevant to think of this zone as having been subjected to one or more periods of metamorphism, but rather to see in it a zone of continual metamorphism lasting from the beginning to the cessation of the tectonic activity affecting it. Any earlier metamorphic episode would likely have been obliterated by subsequent deformation and fluid movement within this zone.

In summary, there is probably no single metamorphic grade that characterizes the entire map area. Conditions during the *circa* 1100 Ma event were in upper amphibolite facies over most of the map area. Within the Fishog subdomain, however, this represents the last of several metamorphic episodes. Within the CMBBZ, metamorphism ceased with the last movement along the CMBBZ, and may have been at lower amphibolite to greenschist facies. More precise geochronologic data in the area will help to put further constraints on the metamorphic history of the area by aiding in the determination of the timing of geologic and structural events.

Structural Geology

Structural trends in the area reflect the trends of the major tectonic zones which constitute the map area. Lithologic units, and in many instances the fabric within the Denna Lake Structural Complex, strike north to northeast, and in general dip shallowly to the southeast. There is considerable local variation, however, related to the chaotic nature of the Denna Lake Structural Complex. No major fold structures occur within this complex, also reflecting the chaotic nature of the complex. However, outcrop-scale folds are present in blocks of metasedimentary and granitoid rocks. Faults are also difficult to identify in the Denna Lake Structural Complex, mainly due to the difficulty in recognizing the lateral offset of rock units within the complex. The ten lithologic subdivisions or zones within the Denna Lake Structural Complex (*see* Figure 8) are probably fault-bounded; graphite occurrences in the Denna Lake Structural Complex may be associated with major faults (*see* "Economic Geology"). Metasedimentary and granitoid rocks within the complex also contain a well-developed lineation that plunges to the southeast at 15 to 25°. The same lineation is present in the Glamorgan Gneiss Complex and the CMBBZ, and appears to be closely related to the CMBBZ. This lineation may postdate the development of the Denna Lake Structural Complex.

In the CMBBZ, trends are more consistent than in the Denna Lake Structural Complex, reflecting the extreme transposition of earlier structures that has occurred in this part of the map area. Gneissosity strikes from north to northeast in the CMBBZ, and except near the contact with the Fishog subdomain, dips within the CMBBZ are shallow to the southeast at 10 to 25°. Dips steepen to 70 to 80° at the contact of the CMBBZ with the Fishog subdomain. The CMBBZ is also characterized by a well-developed, shallow, southeast-plunging lineation. Contacts between units in the CMBBZ may be faulted. The best evidence for faulting along contacts is at the contact between dolomite marbles and straight gneiss exposed on Haliburton County Road 2 north of Pigeon Lake (Photo 15). Here a thin mylonite, less than 25 cm thick, has developed along the contact. Similar mylonites may be present in other contact zones, but if they are of similar thickness, they would be difficult to locate. Contacts between lithologic units in the CMBBZ all dip to the southeast, showing vergence to the northwest. Dips along the contacts steepen from 25° away from the contacts to 45 or 55° at the contacts. Late pegmatite dikes are commonly injected along the contacts and obscure the original nature of the contact. These dikes may indicate some relaxation after the formation of the contact, allowing pegmatite injection. Small isoclinal folds are visible on most outcrops in the CMBBZ, and have axes in the plane of the gneissosity. A few larger folds are also present in the CMBBZ, mainly north of Black Lake (Map 2530, back pocket). These larger fold structures plunge shallowly to the north or south, have axes parallel to gneissosity and fold it, and may repeat lithologic units. A number of kinematic indicators are present in gneisses of the CMBBZ, including rotated feldspar augen, C-S structures, pull-apart structures ("surf" and "turf" structures of Hanmer and Ciesielski 1984) and sheath folds (Hanmer and Ciesielski 1984); all show vergence to the northwest. This vergence is consistent with a model of northwestward-directed thrusting in the Central Gneiss Belt and the CMBBZ proposed by Davidson et al. (1982, 1984), Culshaw et al. (1983) and Hanmer and Ciesielski (1984).

The Fishog subdomain shows a change in structural style from east to west. Near the CMBBZ, structural trends and lithologic contacts have been rotated into north and north-northeast trends parallel to those observed in the CMBBZ. Adjacent to the CMBBZ, Fishog subdomain rocks also contain a prominent southeast-plunging lineation similar to that present in the CMBBZ and the Denna Lake Structural Complex. This lineation is absent, or at least not as well developed, in the western and northwestern parts of the Fishog subdomain. With distance from the CMBBZ, structural trends of map units and gneissosity in the Fishog subdomain, although still commonly north-northeast trending, begin to show more variation, and specific structures such as small scale folds, lineations and fractures can be observed to be localized in certain lithologic units. This is not the case in the eastern part of the map area, where structures are more ubiquitous. Major fold structures occur in the Head Lake area and in the vicinity of Smudge Lake (*see* Figure 5). These structures include the domal structure at Head Lake (Head Lake oval), which is shown both in the distribution of lithologic units and outward dipping gneissosity. A major synform is associated with the Head River anorthosite sheet, and also is reflected in folding of lithologic units and gneissosity. Antiforms and synforms also occur near Smudge Lake, and fold monzonitic rocks of the Smudge Lake plutons. These fold structures are located only in areas underlain by mafic gneisses of unit 3. These fold structures are younger than these gneisses, but older than the granodiorite and granite intrusions (units 11 and 13) of the Fishog subdomain.

The form of plutonic rocks in the Fishog subdomain is influenced by the character of the older gneiss units (units 1, 2 and 3). Lenticular and sill-like plutonic bodies are common in the area west of the Fishog–Victoria lakes mylonite zone, which is dominated by well-layered older gneisses. East of the Fishog–Victoria lakes mylonite zone, plutonic bodies are broader and subcircular in form, and have been intruded into more homogeneous gneisses.

A number of mylonite zones are also present in the Fishog subdomain and are located within 5 km of the CMBBZ. They may be related to the CMBBZ. These mylonite zones separate the area underlain by older gneisses of unit 1, which lacks major fold structures, from the area to the west which is underlain by older layered gneisses (units 2 and 3) and contains major fold structures. Thus, these mylonite zones may have had significant vertical or horizontal displacement associated with them.

Shearing is pronounced in the band of unit 4 gneisses that strikes northeast from the Head River anorthosite to just south of Wolf Lake (*see* Figure 4; Map 2530, back pocket). This shearing, probably due to strain, has been concentrated in the layered gneisses of unit 4 rather than the adjacent, more homogeneous plutonic rocks. Shearing is most intense near Wolf Lake where the zone is narrowest. It is likely that a number of faults parallel to gneissosity may also occur in this zone, at least near Wolf Lake.

Two major fault sets are present in the Fishog subdomain. A north-trending fault set which occurs in the central part of the Fishog subdomain, and which converges near Victoria Lake (*see* Figure 5), and a later, northeast-trending set of faults which cut all units of the subdomain, and which clearly offset lithologic contacts in the area (*see* Figure 4). Near the CMBBZ, these northeast-trending faults begin to splay, and rotate to more northerly trends. None of these faults could be traced into the CMBBZ.

In addition to these major structural features, there may also be a north-south variation in structure across the map area, reflecting a regional tilt. In the southern part of the map area, the oldest rocks of the Fishog subdomain are exposed, as are the best examples of the major fold structures. The mylonite zones of the Fishog subdomain are also widest in the south. The CMBBZ is narrower in the south, and shows fewer lithologic units. In the Denna Lake Structural Complex, white, slightly mineralized pegmatites are more common in the north. All of these features can be explained if there is a slight (5° or less) regional tilt across the map area, which results in slightly deeper crustal levels being exposed in the south. The shallow dips of the lithologic units in the map area would serve to enhance such slight differences in depth or degree of erosion.

Geochronology

The only geochronologic work that has been conducted in the map area was conducted by Easton and Roddick (1988) subsequent to completion of mapping in the area. In addition to dating a trachyandesite dike (unit 34) (*see section on* "Posttectonic Intermediate to Felsic Alkalic Intrusive Rocks") by K-Ar methods, Easton and Roddick (1988) also dated a biotite sample taken from the large outcrop of marble breccia exposed at Miners Bay. This biotite sample yielded a K-Ar biotite age of 1060 ± 14 Ma, which is almost identical to U-Pb zircon ages obtained from deformed pegmatites in the CMBBZ north of Minden (van Breemen and Hanmer 1986). The K-Ar age from Miners Bay is about 120 to 140 Ma older than Ar-Ar ages from biotites from the Bark Lake area northeast of the map area (Berger and York 1981; also see below), suggesting that it is anomalous and probably contains excess argon. Excess argon effects are common in major deformation zones in Ontario (Easton 1985).

Apart from the study by Easton and Roddick (1988) and a few K-Ar ages in the Eels Lake and Burleigh Falls map areas, no other reliable radiometric ages are available for this portion of the Bancroft (Haliburton Highlands) terrane or the Central Gneiss Belt. A number of geochronological studies have been conducted in the Elzevir (Hastings Basin) terrane and the Central Gneiss Belt near Parry Sound, which may be applicable to the timing of geologic events within the Digby–Lutterworth area. These studies are summarized in Table 15, which also indicates possible time relations between these areas and the map area. In general, there is a correspondence of lithologic units and geologic events between the Central Gneiss Belt and the Elzevir terrane, and the Fishog subdomain and the Denna Lake Structural Complex, respectively. However, there are no geochronologic data for two major rock subdivisions in the Digby–Lutterworth area; namely, the "older diorite" group of the Fishog subdomain and the Glamorgan Gneiss Complex.

Argon-argon step-heating ages in the range of 990 + 10 Ma have been obtained from the Bark Lake diorite which intrudes the Glamorgan Gneiss Complex (Berger and York 1981) 35 km east-northeast of the map area. Berger and York (1981) also obtained argon-argon ages of 950 + 10 to 1010 + 10 Ma from hornblendes from the Glamorgan gabbro near Gooderham. These ages are cooling ages, and reflect cooling of rocks below the argon blocking temperature of hornblende, and the end of regional metamorphism in the map area.

TABLE 15. COMPARISON OF GEOCHRONOLOGY DATA FROM THE CENTRAL PART OF THE CENTRAL GNEISS BELT NEAR PARRY SOUND AND FROM THE ELZEVIR TERRANE (HASTINGS BASIN) WITH THE RELATIVE TIMING OF EVENTS IN THE DIGBY–LUTTERWORTH AREA. DATA FOR CENTRAL GNEISS BELT AND ELZEVIR TERRANE IS SUMMARIZED IN EASTON (1985a, 1985b).

Elzevir and Bancroft terranes, Ontario[1]	**Age (in Ma)**[1]	**Central Metasedimentary Belt Boundary Zone and Denna Lake Structural Complex**	
pegmatites	1030 ± 20 (z)[#]	pegmatites in CMBBZ and Denna Lake Structural Complex	deformation to form Denna Lake Structural Complex, last deformation of CMBBZ
metamorphism	1040–1075 (z)	metamorphism of Denna Lake Structural Complex after formation	
posttectonic Plutons	1050–1100 (r, z)	granitoids in Denna Lake Structural Complex	
metamorphism/ isotopic resetting	*circa* 1100 (r)		
syntectonic plutons	*circa* 1105–1120 (r, z)	granitoids in Denna Lake Structural Complex	
syenitic suite plutons and related 'anorthosites'	*circa* 1220–1250 (r, z)	Minden area anorthosites[2]	
mafic intrusions	1240 (r, z)	mafic blocks in Denna Lake Structural Complex?	
early plutons	1230–1250 (r, z)	blocks in Denna Lake Structural Complex?	
volcanism/sedimentation	1250–1280 (r, z)	deposition of carbonates and clastic sediments of Grenville Supergroup	Denna Lake Structural Complex starting material
basement/older rocks	*circa* 1330 (r)	Glamorgan Gneiss Complex	
central part of the Central Gneiss Belt[3]	**Age (in Ma)**[3]	**Fishog Subdomain**	
late tectonic pegmatites	*circa* 1000 (k, z)	late tectonic pegmatites	
metamorphism metamorphism	*circa* 1000 (k) *circa* 1100–1200 (z)		
metamorphism (granulite facies)	*circa* 1240–1260 (r)	not represented?	
plutonism – granite suite	1420 (z)	granite plutons granodiorite plutons	
– granite/ monzonite suite	*circa* 1480–1500 (r)	monzonite suite plutons	
– anorthosite	*circa* 1350–1450 (z)	anorthosite and related rocks	
		older diorite group	

[1] *modified from Table 4, Easton (1986); see Easton (1986) for complete references*

[2] *located on Highway 121, 5 km east of Minden, northeast of Digby–Lutterworth area within the Denna Lake Structural Complex*

[3] *modified from Table 3, Easton (1986); see Easton (1986) for complete references*

[#] *k: K–Ar ages; r: Rb–Sr ages; z: zircon ages*

Aeromagnetic Data

LOCAL MAGNETIC PATTERNS

The comparison of Map 2530 (back pocket) with the available aeromagnetic survey of the map area (Geological Survey of Canada 1984b) indicates only minor, local correlations between aeromagnetic contour patterns and rock types in the Digby–Lutterworth area. For example, the CMBBZ does not have a distinctive aeromagnetic signature, nor are its margins defined magnetically. The Denna Lake Structural Complex, however, has a distinctive aeromagnetic signature, characterized by rapid changes in magnetic gradient and erratic anomaly pattern, and a total field intensity of 1300 to 1700 gammas. The north-south linearity of lithologic units in the Fishog subdomain is not well defined other than near Fishog Lake, nor are the anorthositic and related rocks different in their aeromagnetic signature than the adjacent monzonites and granites. The Head Lake oval is also poorly defined.

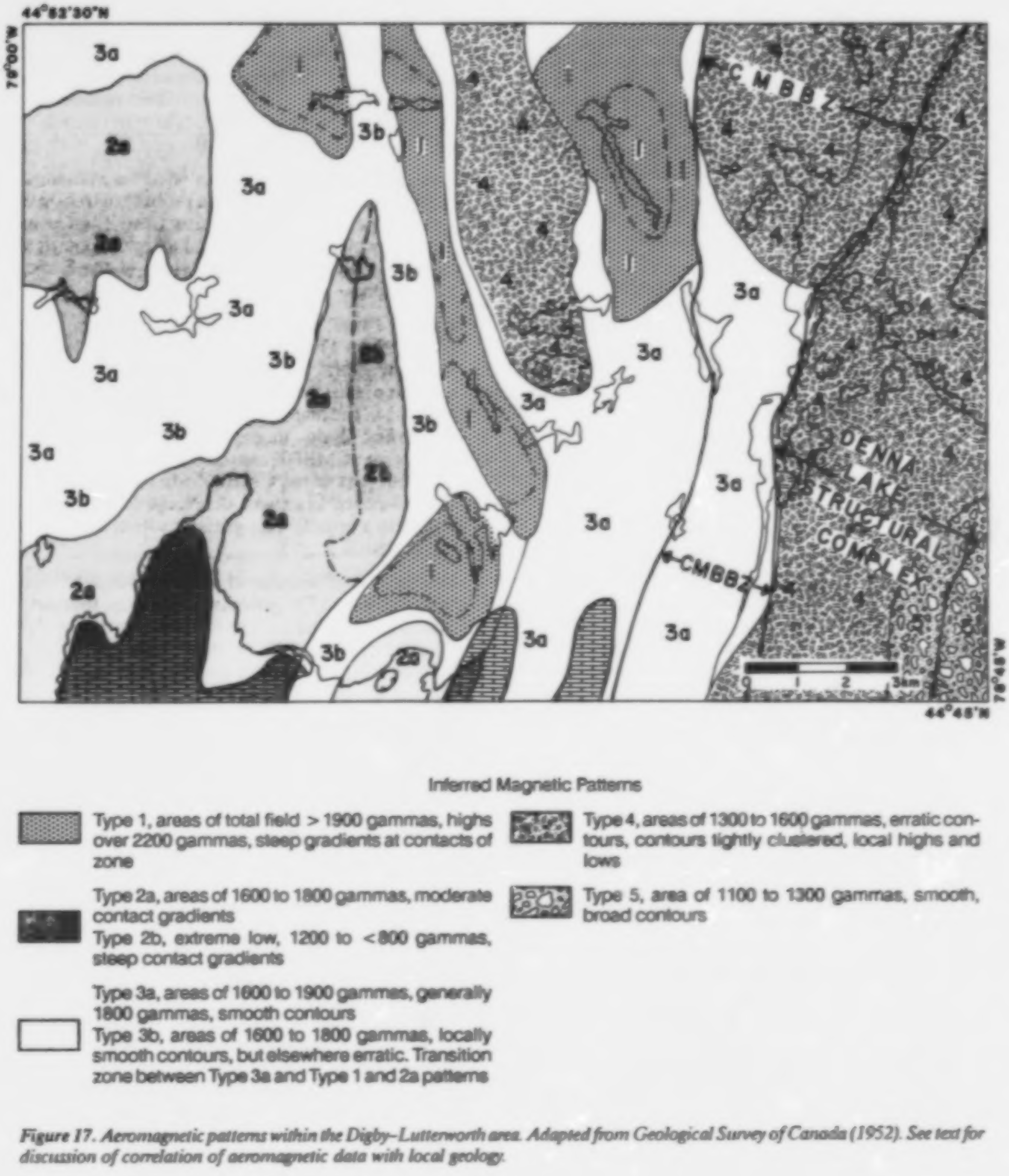
Figure 17 is an interpretive magnetic map for the area, showing the five main types of magnetic patterns present in the map area. What follows is a brief description of these patterns, and their relation to the geology of the area.

- Pattern 1 consists of areas having a total field intensity of 1900 to over 2200 gammas, with steep gradients at their margins. These are the magnetic highs of the area. The band centred on Sheldon Lake is underlain by several plutons of granite gneiss (unit 13), as are the areas north of Head Lake and west of Wolf Lake. The band between Fishog and Victoria lakes is also underlain by gneisses of unit 13, which were intruded into plutons of granodiorite gneiss (unit 11). Pattern 1 is clearly associated with granitic rocks in the Fishog subdomain, but it is not associated with any particular granite type, or even all the pluton boundaries as mapped on the surface.
- Pattern 2a has a subdued magnetic expression, with a total field intensity of 1600 to 1700 gammas. Again, it is associated with granitoid rocks, in this case, monzonite suite rocks north of Smudge Lake and granite gneiss (unit 13) in the southwest part of the map area. However, this pattern does not show the full extent of the plutons, only portions of them.
- Pattern 2b is a significant aeromagnetic low (1200 to less than 800 gammas) present on the east side of a large granite pluton (unit 13) underlying the area of pattern 2a. The origin of this magnetic low is unknown. It could be due to a major fault, or it could be related to a thick section of Quaternary deposits along Fishog Creek, or both.
- Pattern 3a is another subdued pattern, with a total field intensity ranging from 1700 to 1900 gammas. It is underlain mainly by granitic rocks, or marginal phases and hybrid gneiss along the margins of granitic plutons. This pattern is not deflected by the CMBBZ, and straddles the CMBBZ with no dislocation. It is present only in the southern half of the CMBBZ in the map area. It may be related to the composition of the parent rocks as it is this part of the CMBBZ that contains granitoid rocks which may be the disrupted equivalents of granitic rocks in the adjacent Fishog subdomain.
- Pattern 3b is more erratic than 3a, and is located adjacent to patterns 1 and 2a. It is probably a transition between pattern 3a and patterns 1 and 2 and is underlain by migmatitic rocks and marginal phases to the monzonite and granite plutons of the Fishog subdomain.
- Pattern 4 is an erratic pattern ranging in intensity from 1300 to 1700 gammas. It occurs in the Denna Lake Structural Complex, and overlaps the northern part of the CMBBZ. It is also present in the central part of the map area, in an area underlain by tonalitic and dioritic migmatitic rocks of unit 1. The area of the CMBBZ characterized by pattern 4 is also that part of the CMBBZ where there is some field evidence to suggest that some rocks of unit 1 served as a protolith for gneisses within this part of the CMBBZ.
- Pattern 5 is in an area of subdued magnetic contours, 1000 to 1300 gammas in intensity, that characterizes almost all of the Howland area to the east. The western margin of the Glamorgan Gneiss Complex locally parallels the 1300 gamma contour, but not consistently across the area.

In summary, the aeromagnetic data for the map area can be broadly correlated with known geology. The aeromagnetic data are more closely tied to bulk rock composition than to regional tectonic structures.

REGIONAL MAGNETIC PATTERNS

Figure 18 shows in a generalized form the residual total field aeromagnetic data (Geological Survey of Canada 1984b) for the southern Grenville Province, superimposed on a map showing the main tectonic elements of the region. In general, there is an association between regional aeromagnetic patterns and regional structures, for example, the Harvey–Cardiff arch and the Parry Sound domain. The Fishog subdomain both in and adjacent to the map area is distinctive in its magnetic expression when compared to the adjacent Muskoka domain. Thus, the Fishog subdomain may indeed be a distinct tectonic entity rather than a subdivision of the Muskoka domain. Further mapping along the western and northern boundaries of the Fishog subdomain is needed in order to test this possibility.


44°52'30"N
79°00'W
3a
2a
2a
3a
3b
3b
3a
3b
2b
2a
3b
3a
3b
3a
3b
2b
2a
2a
3b
2a
3a
3a
3a
3a
3a
3a
CMBBZ
CMBBZ
DENNA LAKE STRUCTURAL COMPLEX
4
4
4
4
0
1
2
3km
78°45'W
44°45'N

Inferred Magnetic Patterns

▨ Type 1, areas of total field > 1900 gammas, highs over 2200 gammas, steep gradients at contacts of zone

■ Type 2a, areas of 1600 to 1800 gammas, moderate contact gradients
Type 2b, extreme low, 1200 to < 800 gammas, steep contact gradients

☐ Type 3a, areas of 1600 to 1900 gammas, generally 1800 gammas, smooth contours
Type 3b, areas of 1600 to 1800 gammas, locally smooth contours, but elsewhere erratic. Transition zone between Type 3a and Type 1 and 2a patterns

▨ Type 4, areas of 1300 to 1600 gammas, erratic contours, contours tightly clustered, local highs and lows

▨ Type 5, area of 1100 to 1300 gammas, smooth, broad contours

Figure 17. Aeromagnetic patterns within the Digby–Lutterworth area. Adapted from Geological Survey of Canada (1952). See text for discussion of correlation of aeromagnetic data with local geology.

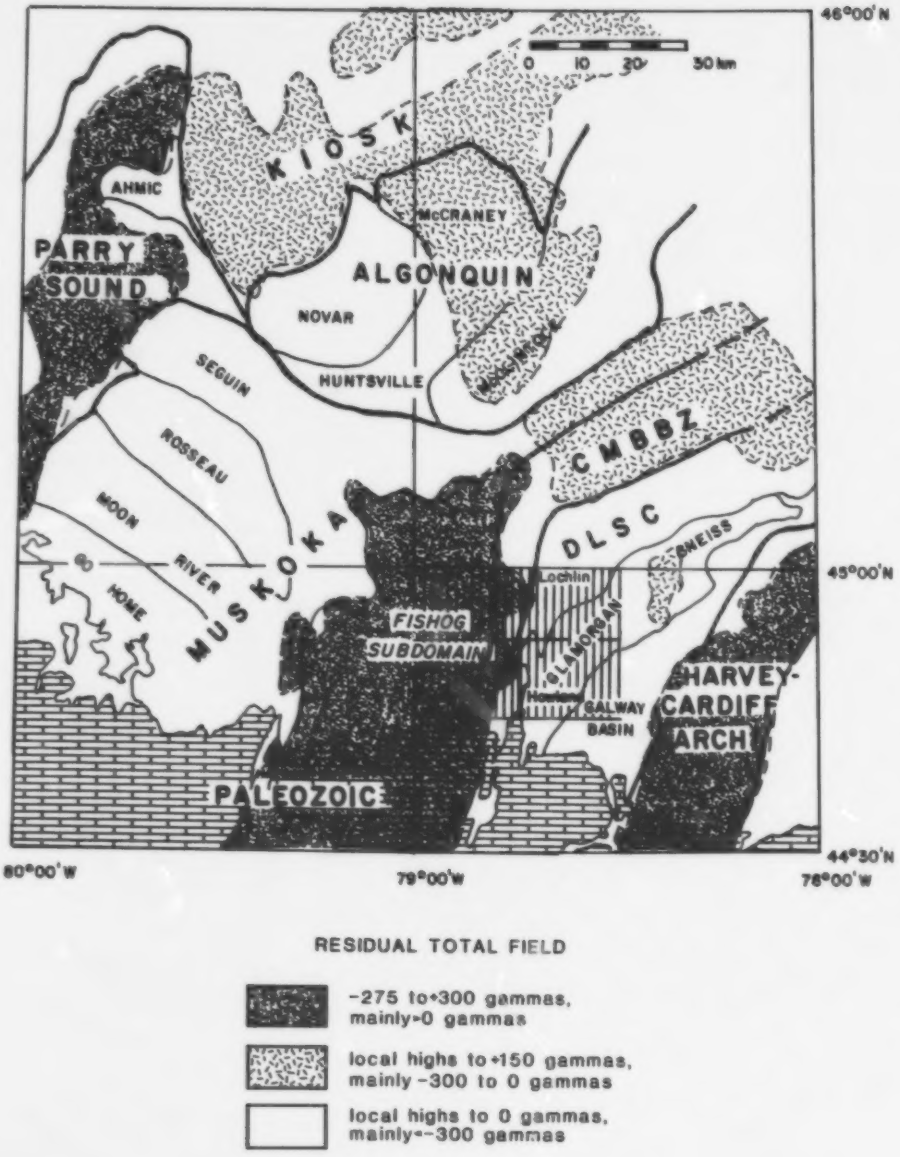

46°00'N
0 10 20 30 km
KIOSK
AHMIC
PARRY SOUND
McCRANEY
ALGONQUIN
NOVAR
SEGUIN
HUNTSVILLE
MCCLINTOCK
CMBBZ
ROSSEAU
MOON RIVER
HOME
MUSKOKA
DLSC
GNEISS
45°00'N
Lochlin
FISHOG SUBDOMAIN
GLAMORGAN
Howland
GALWAY BASIN
HARVEY-CARDIFF ARCH
PALEOZOIC
44°30'N
80°00'W
79°00'W
78°00'W
RESIDUAL TOTAL FIELD
-275 to+300 gammas, mainly>0 gammas
local highs to+150 gammas, mainly -300 to 0 gammas
local highs to 0 gammas, mainly<-300 gammas

Figure 18. Total field residual magnetic anomalies and major tectonic structures, southwestern Grenville Province. Domain and subdomain boundaries after Culshaw et al. (1983). The Fishog subdomain boundary is based on interpretation of aerial photographs and maps of Baer et al. (1977) and Schwerdtner and Mawer (1982), and is only an approximation. CMBBZ = Central Metasedimentary Belt Boundary Zone; DLSC = Denna Lake Structural Complex. The area southeast of the CMBBZ is the Central Metasedimentary Belt; areas west and north are the Central Gneiss Belt. Aeromagnetic data simplified from Geological Survey of Canada (1984b).

Airborne Gamma Ray Spectrometric Data

Airborne gamma ray spectrometric coverage of the Digby–Lutterworth area is available at two scales: 1:250 000 scale (Ontario Geological Survey 1978) and 1:50 000 scale (Geological Survey of Canada 1984a, 1984b). In addition, private airborne surveys conducted by Hans Lundberg in 1954 and Jorex Ltd. (now Canadian Jorex Limited, name changed in 1984) in 1978, over Lutterworth and the northwestern part of Somerville townships (Assessment Files Research Office, Ontario Geological Survey, Toronto—hereafter referred to as AFRO). The two government data sets show similar regional patterns, but anomalies in the area are better defined by the 1:50 000 scale coverage.

Figure 19 shows a simplified version of the gamma ray coverage at 1:50 000 scale for the Digby–Lutterworth area expressed as the equivalent Thorium (eTh) contours in parts per million (ppm), superimposed on a generalized geologic map of the area (the distribution of known radioactive mineral occurrences is also shown). Known radioactive mineral occurrences all lie within the area defined by the eTh 5 ppm or greater contour line. The equivalent Uranium (eU) map (not shown) shows a similar pattern, although the anomalies are areally less extensive than on the eTh map, and no eU anomalies are present west of Gull Lake. Both the eU and eTh maps show a pronounced high associated with the Denna Lake Structural Complex, which is also a zone of abundant pegmatite injection. In the adjacent Howland area to the east, known radioactive mineral occurrences are always found associated with airborne gamma ray spectrometric anomalies (>2 ppm eU or

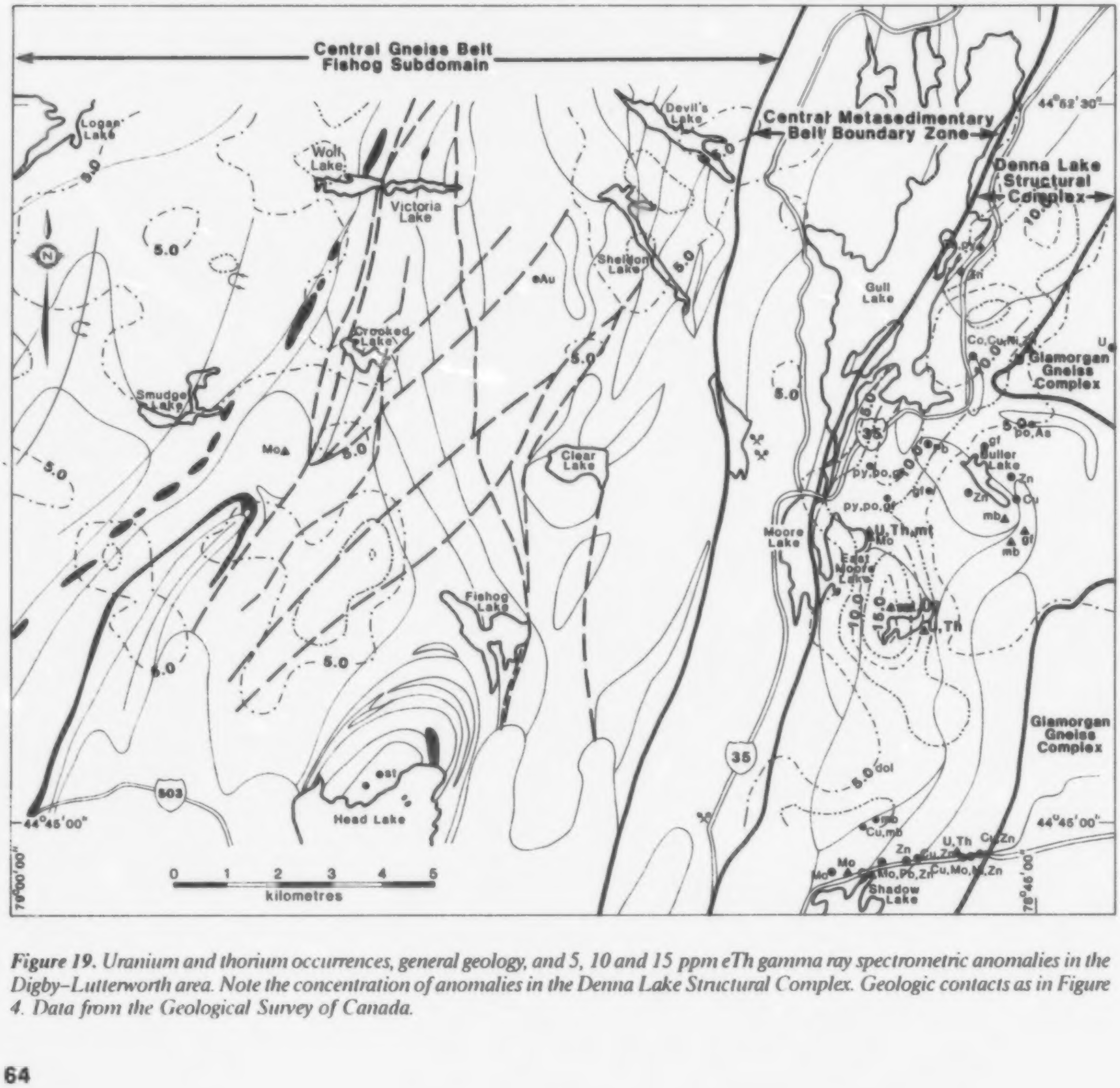

Central Gneiss Belt
Fishog Subdomain
Logan Lake
5.0
Wolf Lake
Victoria Lake
Devil's Lake
Central Metasedimentary Belt Boundary Zone
44°52'30"
Denna Lake Structural Complex
Sheldon Lake
Au
Gull Lake
Zn
Co,Cu,Ni,Zn
U
Glamorgan Gneiss Complex
Crooked Lake
Smudge Lake
Mo
35
po,As
gf
Fuller Lake
Cu
Clear Lake
py,po,gf
Moore Lake
U,Th,mt
East Moore Lake
10.0
15.0
U,Th
mb
Fishog Lake
est
Head Lake
503
dol
Cu,mb
Cu,Zn
Mo,Pb,Zn
Cu,Mo,Ni,Zn
Shadow Lake
44°45'00"
78°00'00"
78°45'00"
0 1 2 3 4 5
kilometres

Figure 19. Uranium and thorium occurrences, general geology, and 5, 10 and 15 ppm eTh gamma ray spectrometric anomalies in the Digby–Lutterworth area. Note the concentration of anomalies in the Denna Lake Structural Complex. Geologic contacts as in Figure 4. Data from the Geological Survey of Canada.

>5 ppm Th, or both); this is, therefore, a reliable exploration tool for radioactive minerals in the area (Easton and Bartlett 1984; Easton 1987a). It would appear that this is also the case for the Digby–Lutterworth area, given the correspondence between the gamma ray anomalies and known radioactive mineral occurrences in the area.

A large anomaly in both eU and eTh is located along the Ontario Hydro transmission line about 2 km northwest of South Beaver Lake (lots 20 and 21, concession 4, Lutterworth Township). A ground survey near the centre of the anomaly conducted by field party personnel registered no abnormal scintillometer readings, and samples collected by field party personnel for assay tested negative for radioactive minerals. Lundberg noted a similar anomaly in 1954, but was unable to locate its source (AFRO). It is possible that the anomaly may be in some way related to the Ontario Hydro transmission line. However, uranium occurrences are present along the margins of the anomalous area (Figure 19), and a yet undiscovered occurrence may be the source of the anomaly.

Geological Synthesis

Davidson et al. (1982) recognized that the Central Gneiss Belt of the Grenville Structural Province consisted of a number of crustal segments, or domains, separated from each other by high strain or mylonite zones. Davidson et al. (1982) proposed a model of northwest-directed thrusting related to a continental collisional event at *circa* 1100 Ma to explain these and other field observations. Subsequent work by Davidson and co-workers (Davidson et al. 1984; Culshaw et al. 1983; Hanmer and Ciesielski 1984) has led to further refinement of the original model, but its essential elements have remained intact. Several elements of the geology of the Digby–Lutterworth area can be best explained using the model of northwest-directed thrusting, and are elaborated upon below.

As mentioned in the introduction to the section on the Fishog subdomain and in the section on Aeromagnetic Data, rocks within the Fishog subdomain are distinct from typical Muskoka domain rocks, and the Fishog subdomain has a unique aeromagnetic signature. Granulite facies mineral assemblages are absent from the eastern part of the Fishog subdomain. It is possible that the Fishog subdomain is another crustal segment (domain) of the Central Gneiss Belt, and it may structurally overlie the Muskoka domain. It has rock types distinct from typical Muskoka domain rocks (*see* Culshaw et al. 1983), it has distinct structural trends (e.g., Schwerdtner and Mawer 1982), it may be metamorphically distinct (only local or no development of granulite facies metamorphism), and is aeromagnetically distinctive. Further mapping in the western Fishog subdomain is needed to demonstrate that this region is indeed different from the Muskoka domain. In this report, the Fishog subdomain is tentatively called a subdomain of the Muskoka domain, although it may later be demonstrated to be a true domain. Figure 20 shows the stacking sequence of domains or crustal plates in the western part of the Central Gneiss Belt, and the possible position of the Fishog subdomain in the sequence. The CMBBZ and the Denna Lake Structural Complex would in turn structurally overlie the Fishog subdomain.

In addition, some aspects of the local geology of the Digby–Lutterworth area can be explained by a model of northwest-directed thrusting. These aspects are illustrated in Figure 21, which shows possible lithotectonic plates within the map area, and their apparent stacking sequence. The most significant of these to local geology are in the Denna Lake Structural Complex, where the stacking sequence may be determined in part by original stratigraphic relations. Since the lithologic types within the Denna Lake Structural Complex can be correlated with Grenville Supergroup strata in the Howland area (*see* Figure 9), it is possible to use this ghost stratigraphic sequence to determine possible stacking order. In the Denna Lake Structural Complex, the highest level blocks, on the basis of the ghost stratigraphy, are also topographic highs, and in the case of the Buller Lake block, some evidence of a fault-bounded contact is present. Also shown in Figure 21, and elaborated upon in the sections on the CMBBZ and Aeromagnetic Data, is the fact that the western part of the CMBBZ may be largely derived from the disaggregation and disruption of Fishog subdomain rocks. Also apparent from Figure 21 is that the boundaries of the possible blocks in the Fishog subdomain do not correspond to the distribution of the anorthositic rocks (Figure 6). The boundaries of the blocks are based on the presence of major mylonite or shear zones in the area, or major lithologic discontinuities, or both. Anorthositic rocks are not related to these mylonite or shear zones.

A related question is what constitutes the boundary between the Central Metasedimentary Belt and the Central Gneiss Belt. Certainly, the CMBBZ is a fundamental part of this boundary. But the Denna Lake Structural Complex has been tectonically disaggregated, apparently roughly contemporaneously with the formation of the CMBBZ. The main difference between the two is compositional, one is composed of tectonites, the other of brecciated supracrustal rocks. Historically, the marble units, whether brecciated or not were considered to be part of the Central Metasedimentary Belt (e.g., Wynne-Edwards 1972). This also seems to be the approach followed by Davidson et al. (1982, 1984), and would seem to be the most practical. For ex-

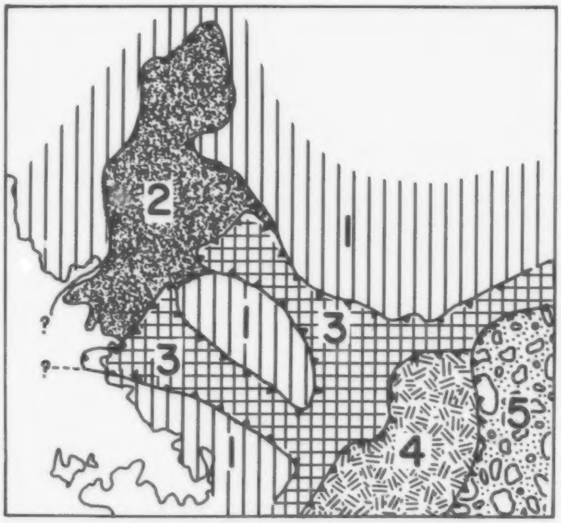


Figure 20. Major structural subdivisions, southwestern Grenville Province. Domain and subdomain boundaries from Culshaw et al. (1983). Key: (1) Algonquin and Britt domains; (2) Parry Sound domain; (3) Moon River and Raveau domains; (4) Fishog subdomain; and, (5) Central Metasedimentary Belt (includes Central Metasedimentary Belt Boundary Zone). Fishog subdomain boundary is only an approximation and is subject to change.

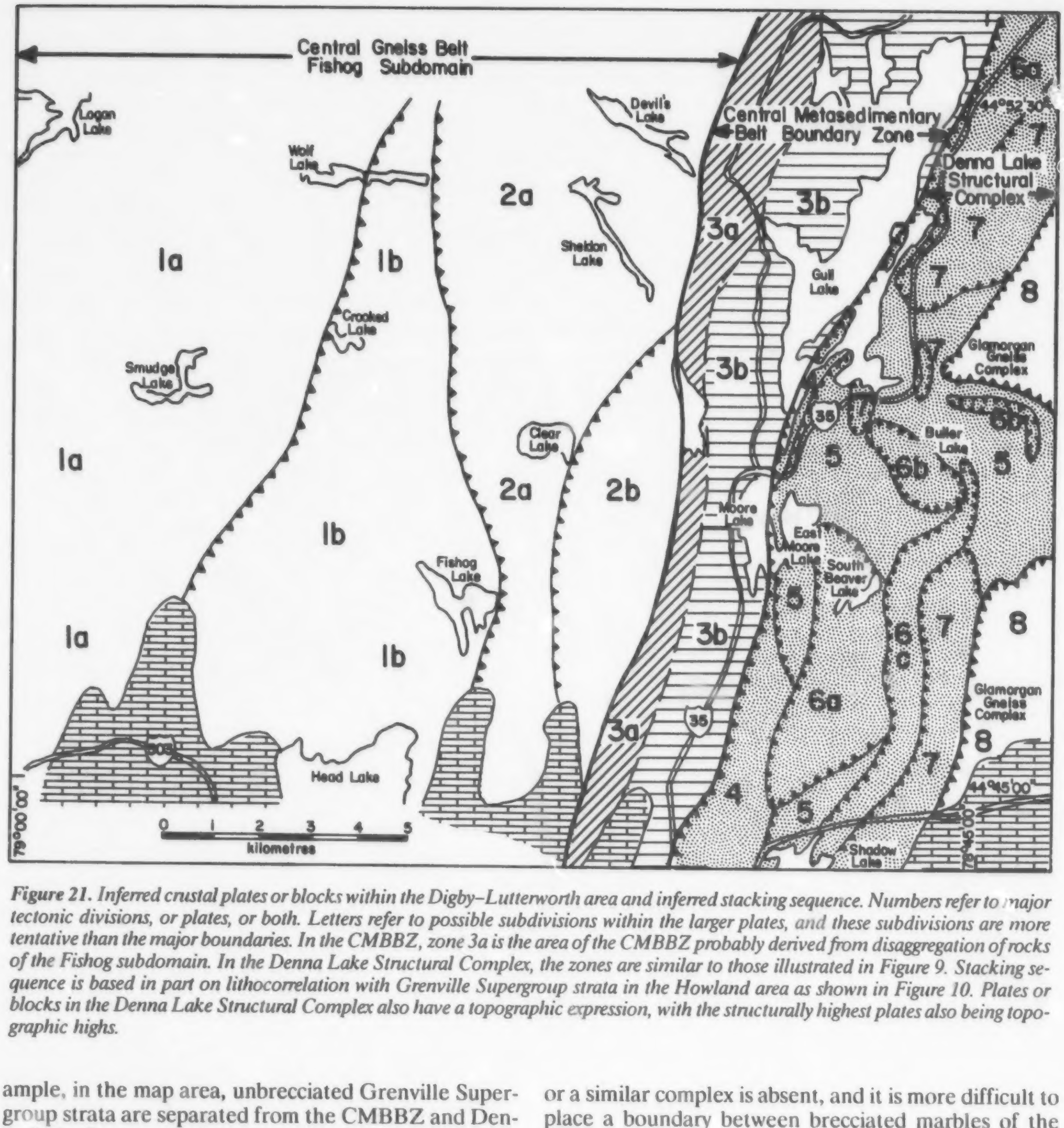

Central Gneiss Belt
Fishog Subdomain
Logan Lake
Wolf Lake
Devil's Lake
Central Metasedimentary Belt Boundary Zone
Denna Lake Structural Complex
44°52'30"
1a
1b
2a
2b
3a
3b
4
5
6a
6b
6c
7
8
Sheldon Lake
Gull Lake
Crooked Lake
Smudge Lake
Glamorgan Gneiss Complex
35
Buller Lake
Clear Lake
Moore Lake
East Moore Lake
South Beaver Lake
Fishog Lake
503
Head Lake
44°45'00"
78°00'00"
78°45'00"
Shadow Lake
0 1 2 3 4 5
kilometres

Figure 21. Inferred crustal plates or blocks within the Digby–Lutterworth area and inferred stacking sequence. Numbers refer to major tectonic divisions, or plates, or both. Letters refer to possible subdivisions within the larger plates, and these subdivisions are more tentative than the major boundaries. In the CMBBZ, zone 3a is the area of the CMBBZ probably derived from disaggregation of rocks of the Fishog subdomain. In the Denna Lake Structural Complex, the zones are similar to those illustrated in Figure 9. Stacking sequence is based in part on lithocorrelation with Grenville Supergroup strata in the Howland area as shown in Figure 10. Plates or blocks in the Denna Lake Structural Complex also have a topographic expression, with the structurally highest plates also being topographic highs.

ample, in the map area, unbrecciated Grenville Supergroup strata are separated from the CMBBZ and Denna Lake Structural Complex by the Glamorgan Gneiss Complex. In this area, the boundary is easily defined, i.e., the western margin of either the Glamorgan Gneiss Complex or the Denna Lake Structural Complex. In the Haliburton area, however, at least three sheets of marble breccia separated by sheets of tonalite gneiss are present between the CMBBZ and the Glamorgan Gneiss Complex. Here, a well-defined boundary is not present. Further east, the Glamorgan Gneiss Complex or a similar complex is absent, and it is more difficult to place a boundary between brecciated marbles of the Denna Lake Structural Complex and unbrecciated marbles of the Grenville Supergroup. Until the boundary between the Central Metasedimentary Belt and the Central Gneiss Belt has been mapped in greater detail along its length, the historic boundary of the Central Metasedimentary Belt is the most practical for mapping purposes, and the Denna Lake Structural Complex must be considered to be a part of the Central Metasedimentary belt, albeit a disrupted, marginal phase to it.

Economic Geology

The Digby–Lutterworth area contains a variety of metallic and nonmetallic mineral occurrences, but the only producers are two currently operating stone quarries located in the eastern part of the map area.

Most mineral occurrences are located within the Denna Lake Structural Complex, and consist of zinc and copper sulphides with traces of arsenic, cobalt, lead, molybdenum and nickel. The zinc sulphides are commonly present in dolomitic marbles. Molybdenum mineralization is located in the southwest part of the map area and near Miners Bay. The CMBBZ and the Fishog subdomain contain only a gold and a molybdenum occurrence.

Radioactive mineralization is limited to uranium and thorium concentrations in syenite pegmatite veins, and the larger occurrences are associated with regional gamma ray spectrometric anomalies. All known occurrences are located in the Denna Lake Structural Complex.

Nonmetallic minerals consist of graphite, tremolite and relatively pure dolomite and calcite marbles. Two stone quarries located in the CMBBZ produce flagstone for building and ornamental purposes; the CMBBZ has a high potential for these types of stone production. Sand and gravel deposits are also present in the area, and are located mainly along the Gull River system in the southern part of the map area.

Carter (1984) classed metallic mineral deposits in the Central Metasedimentary Belt of Ontario into four main types (Table 16). Carter (1984) also summarized the relationships between mineralization and regional geologic events in the Central Metasedimentary Belt (Figure 22). Specific types of mineralization were controlled in time and space by stratigraphy and later magmatic events. The classification scheme of Carter (1984) has only limited application to mineral exploration in the Digby–Lutterworth area. This is because of the subsequent tectonic deformation of Grenville Supergroup strata to form the Denna Lake Structural Complex; stratigraphy in the complex is no longer intact. In addition, the western part of the Central Metasedimentary Belt contains few volcanic rocks, which host many mineral deposits further to the east (Figure 22). Nevertheless, certain associations are observed between metallic mineral occurrences within the Denna Lake Structural Complex, which may have had their origin in the stratigraphy present in the Grenville Supergroup prior to tectonic disruption. In addition, as has been discussed in detail under the section on the Denna Lake Structural Complex, large blocks or domains within the Denna Lake Structural Complex probably reflect, at least in part, the original stratigraphy of the Grenville Supergroup (Figure 22). The localization of zinc occurrences within dolomite marble and the distribution of molybdenum occurrences in the Denna Lake Structural Complex are two examples of how original stratigraphic relations control the distribution of mineral deposits in this now tectonically disrupted terrane.

Figure 22 has been modified from Carter (1984) and illustrates some of the associations between blocks or domains in the Denna Lake Structural Complex and the mineralization likely to be present. Figures 22 and 9 outline how these domains in the Denna Lake Structural Complex may relate to the original stratigraphy prior to tectonic disruption. Table 17 is a list of occurrences and deposits in the map area and is keyed to Map 2530 (back pocket). These occurrences are described in detail later in the text. Figure 23 is a map showing the mineral potential for various parts of the Digby–Lutterworth area, based on the present geological survey and on a review of assessment work and reported occurrences in the map area.

Unless otherwise indicated, assay results reported in the Economic Geology section of this report were performed by the Geoscience Laboratories Section, Ontario Geological Survey, Toronto. Elements analyzed for in each assay are: aluminum, arsenic, barium, calcium, cerium, chromium, cobalt, copper, gold, iron, lanthanum, lead, magnesium, molybdenum, nickel, niobium, neodymium, silver, strontium, titanium, thorium, vanadium, yttrium, zinc and zirconium. Only anomalous values are reported in the text.

TABLE 16. GENETIC CLASSIFICATION OF METALLIC MINERAL DEPOSITS IN THE GRENVILLE PROVINCE, SOUTHEASTERN ONTARIO (AFTER CARTER 1984). Dagger indicates deposit types present in the Denna Lake Structural Complex in the Digby–Lutterworth area. Asterisk indicates deposit types which may be present in the area on the basis of stratigraphy. No asterisk indicates deposit types unlikely to occur in the map area.

1. SYNGENETIC VOLCANIC AND SEDIMENTARY DEPOSITS
    - A. Strata-bound pyritic sulfides*
    - B. Stratiform zinc†
    - C. Stratiform Cu-Sb-Ag-Hg-barite
    - D. Stratiform quartz-magnetite ironstone
    - E. Stratiform magnesium*
2. SYNGENETIC MAGMATIC DEPOSITS
    - A. Copper-nickel*
    - B. Iron-titanium
3. EPIGENETIC DEPOSITS
    - A. Contact metasomatic iron†
    - B. Gold-quartz vein*
    - C. Metamorphic-metasomatic molybdenum†
    - D. Uranium†
    - E. Post-Ordovician Ba-F-Sr-Pb veins
4. SUPERGENE DEPOSITS
    - A. Hematite*

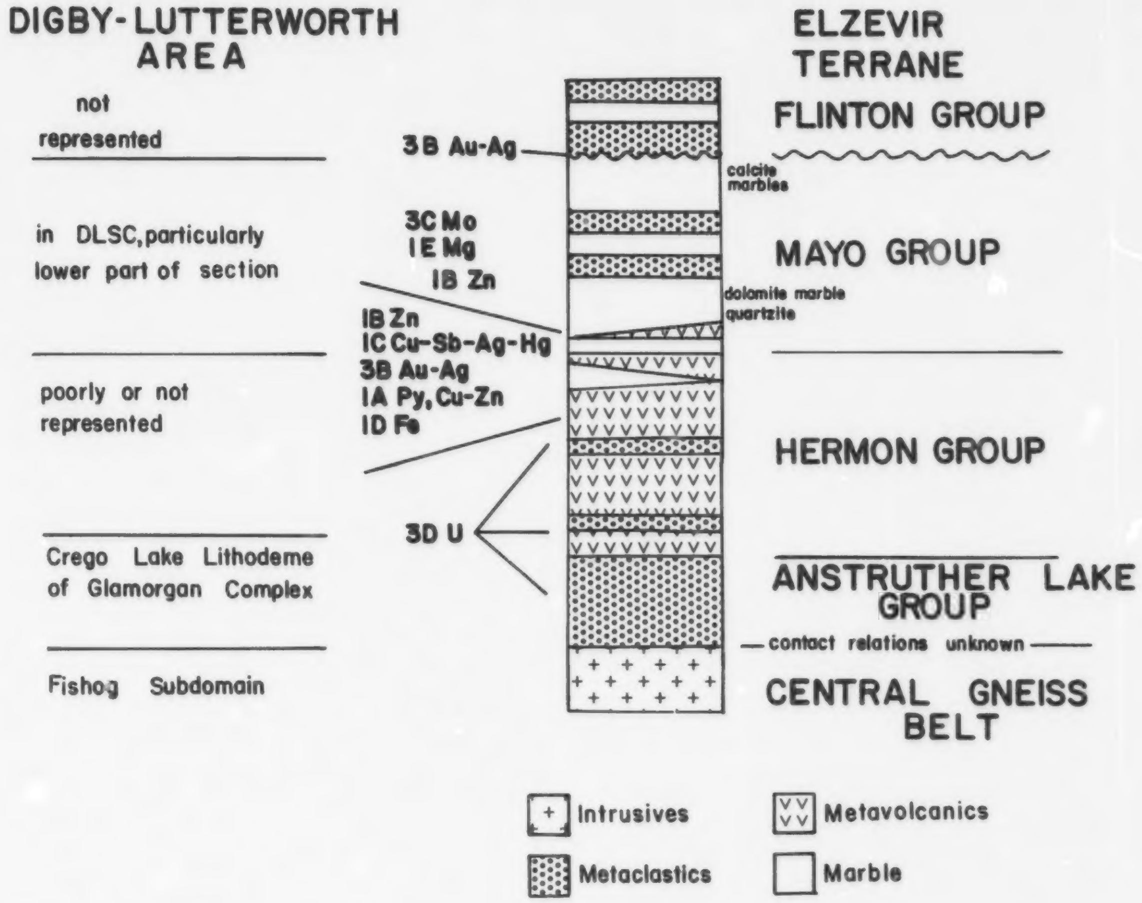

DIGBY-LUTTERWORTH AREA
not represented
in DLSC, particularly lower part of section
poorly or not represented
Crego Lake Lithodeme of Glamorgan Complex
Fishog Subdomain
3B Au-Ag
3C Mo
1E Mg
1B Zn
1B Zn
1C Cu-Sb-Ag-Hg
3B Au-Ag
1A Py, Cu-Zn
1D Fe
3D U
calcite marbles
dolomite marble
quartzite
ELZEVIR TERRANE
FLINTON GROUP
MAYO GROUP
HERMON GROUP
ANSTRUTHER LAKE GROUP
— contact relations unknown —
CENTRAL GNEISS BELT
Intrusives
Metavolcanics
Metaclastics
Marble

Figure 22. Interpreted stratigraphic associations of metallic mineral deposits within the Grenville supergroup in southeastern Ontario (after Carter 1984). Possible associations present in the tectonically disrupted Denna Lake Structural Complex (DLSC) are shown for comparison. Many deposit types are not represented in the Digby–Lutterworth area as metavolcanic rocks of the Hermon Group are not common in this part of the Central Metasedimentary Belt. For key to numbers 1A, 1B, etc. see Table 16.

PROSPECTING AND MINING ACTIVITY

Recorded data on mineral occurrences in the map area date back to the late 1800s, in the work of F.D. Adams (1894) who worked for the Geological Survey of Canada. Active prospecting in these early years was limited to scattered pits and trenches, although in the adjacent Howland area to the east, the Paxton, Howland and Victoria iron mines were developed and put into production (Easton 1987a). These mines had ceased operation by 1895. Mineral exploration in the Miners Bay region of the map area was spurred at this time by rumours of a lead-silver mine that was located near Miners Bay and whose location was known only to local Indian bands (Reynolds 1968; Adams 1894). This mine was never located, and it is possible that local occurrences of molybdenite may have been mistaken for silver. A similar rush for gold at Shadow Lake south of the map area at this time turned out to be due to the presence of pyrite mistakenly identified as gold.

Other exploration in this period led to the surface development of molybdenite occurrences, as summarized by Adams and Barlow (1910), mostly around the shores of East Moore Lake (occurrences 17 and 18). J. Satterly of the Ontario Department of Mines compiled much of the data available on the early showings and re-examined some of the properties (Satterly 1943). No exploration work is recorded in the map area between 1918 and 1954. Overall, exploration activity in the Digby–Lutterworth area has been minimal, especially when compared to the amount of exploration activity that has occurred further east (e.g., Bright 1980).

Renewed interest in the area between 1954 and 1957 was coincident with the exploration boom for uranium in the Bancroft area in the mid-1950s. Hans Lundberg conducted an airborne radiation survey over Lutterworth Township in 1954, and identified anomalies in the vicinity of South Beaver Lake (occurrence 8), East Moore Lake (occurrence 16), and at Shadow Lake, 3 km

TABLE 17. PRODUCERS AND OCCURRENCES LOCATED IN THE DIGBY–LUTTERWORTH AREA.

Reference Number	Number	Commodity
PRODUCERS		
1	Saikonnen (Black Lake)	st
2*	Laxton, Lot 10, Conc. 10	st
OCCURRENCES		
3	Lutterworth, Lot 16, Conc. 4, 5	mb
4*	Digby, Lots 17 to 20, Conc. 1	st
5	Digby, Lot 16, Conc. 7	Mo
6	Digby, Lots 2 to 10, Conc 8 to 11	Au
7*	Luttherworth, Lot 26, Conc. 1	dol
8	Jorex Ltd.	U
9	Lutterworth, Lot 15, Conc. 4	gf
10*	Lutterworth, Lot 15, Conc. 4	Zn
11	Arbuckle	U (mt)
12	Lutterworth, Lot 15N, Conc. 5	Zn
13*	Lutterworth, Lot 15S, Conc. 5	Cu
14*	Lutterworth, Lot 29, Conc. 5	gf
15*	Lutterworth, Lot 20, Conc. 5	gf, po, py
16	Lundberg	U (mt)
17	Lutterworth, Lot 11, Conc. 5	Mo (U)
18	Lutterworth, Lot 23, Conc. 5	Mo (U)
19*	Lutterworth, Lot 13, Conc. 6	po, As
20*	Lutterworth, Lot 16, Conc. 6	gf
21*	Lutterworth, Lot 18, Conc. 6	Pb
22*	Lutterworth, Lot 21, Conc. 6	gf, po, py
23	Hogan	U, Th
24*	Lutterworth, Lot 15, Conc. 7	Co, Cu, Zn (Ni)
25*	Lutterworth, Lot 14, Conc. 8	Zn
26*	Lutterworth, Lot 12, Conc. 9	Zn, py
27*	Somerville, Lots 2, 3, Conc. B	mb, Co, Cu, Zn

ABBREVIATIONS

As – arsenic
Au – gold
Co – cobalt
Cu – copper
dol – dolomite
gf – graphite
mb – marble
Mo – molybdenum
mt – magnetite
Ni – nickel
Pb – lead
po – pyrrhotite
py – pyrite
st – stone
U – uranium
Zn – zinc

**newly reported occurrence, trench or pit located by field party personnel. Reference numbers correspond to numbers on Map 2530 (back pocket). Commodity listed in brackets is of minor or secondary importance.*

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south of the southeast corner of the map area. F. Arbuckle also located uranium near East Moore Lake in 1956 (occurrence 11). Uranium exploration ceased after 1957, and did not begin again until 1978, when Jorex Ltd. (now Canadian Jorex Limited, name changed in 1984) conducted an airborne gamma ray survey over the eastern half of Lutterworth Township in 1978, and in 1978 and 1979 conducted geological surveys and diamond drilling on the South Beaver Lake (occurrence 8) and Shadow Lake properties found previously by Lundberg. Low-grade uranium mineralization was found on both properties (AFRO).

St. Joseph Explorations Ltd. (now Sulpetro Minerals Ltd., name changed in 1981) conducted extensive geophysical surveys over Buller Lake between 1976 and 1981 (AFRO) while exploring for zinc. The outcome of this exploration program is not known, but it concentrated on dolomite marbles in the Buller Lake area, a favourable setting for zinc mineralization in the Grenville Province (Carter 1984).

A flagstone quarry was put into operation near Black Lake (occurrence 1) by K. Saikonnen in 1963, and was apparently still in limited operation in 1984. A second flagstone quarry was also in operation in 1984 in Laxton Township adjacent to Highway 35 (occurrence 2). Several sand and gravel pits are also present within the map area.

Exploration activity in the past has concentrated in the eastern third of the map area, while the central and western parts of the map area, underlain mainly by granitoid rocks, have remained virtually untouched by exploration activity.

Field party personnel located several new mineral occurrences in the map area, both by field work and by assay. These newly reported occurrences are indicated in Table 17, which lists known mineral occurrences with-

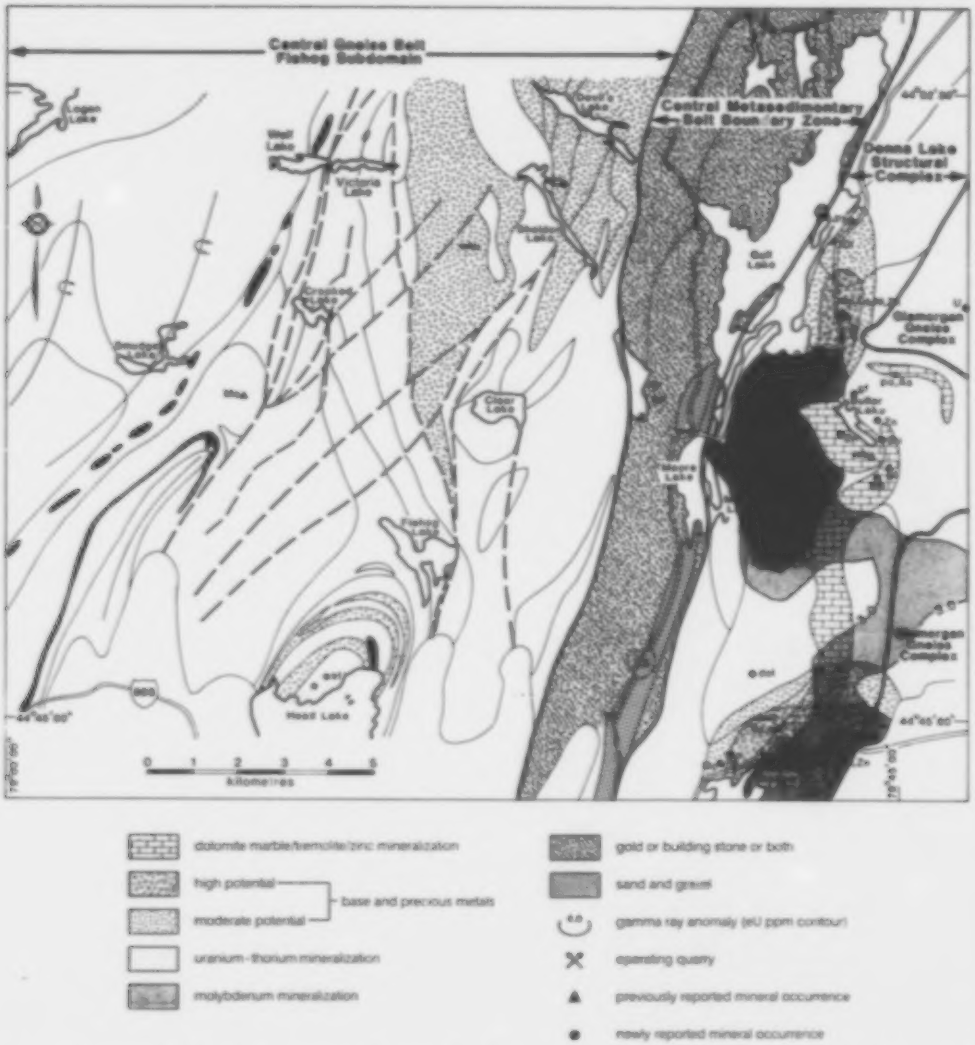
Central Gneiss Belt
Fishog Subdomain
Central Metasedimentary Belt Boundary Zone
Denna Lake Structural Complex
Glamorgan Gneiss Complex
Logan Lake
Wolf Lake
Victoria Lake
Devil's Lake
Gull Lake
Clear Lake
Moore Lake
Fishog Lake
Hood Lake
44°45'00"
0 1 2 3 4 5
kilometres
dolomite marble/tremolite/zinc mineralization
high potential
moderate potential
base and precious metals
uranium-thorium mineralization
molybdenum mineralization
gold or building stone or both
sand and gravel
gamma ray anomaly (eU ppm contour)
operating quarry
previously reported mineral occurrence
newly reported mineral occurrence

Figure 23. Mineral potential of the Digby–Lutterworth area. In addition to the commodities listed, the Fishog subdomain has potential for Fe-Ti ores associated with anorthositic rocks, and Nb-Zr ores associated with granitic plutons. The potential of these latter two commodities is based on their association with rocks of similar age and composition elsewhere in Grenville Province, and have not yet been reported from the map area.

in the Digby-Lutterworth area. Background levels are based on representative rock samples collected in 1983 and 1984 by the author.

METALLIC MINERALIZATION

GOLD

Only one occurrence of gold (occurrence 6) has been reported from the map area and is described below. It is located in mafic gneisses (unit 1) of the Fishog subdomain.

Deformed and sheared rocks within the CMBBZ may also be favourable hosts for gold, as shear zones in Archean terranes are commonly associated with gold. However, 25 samples from this zone collected by field party personnel for assay all contained less than 0.01 ounce per ton gold (< 0.34 ppm). The location of these samples is shown in Figure 24.

No gold occurrences have been reported from the Denna Lake Structural Complex. A gold rush near Shadow Lake south of the map area in the late 1800s was due to misidentified pyrite (Adams 1894). Carter (1984) has noted that gold deposits in the Central Metasedimentary Belt of the Grenville Structural Province are closely associated with greenschist facies metamorphic rocks, or near the transition between greenschist and amphibolite facies. If so, then the upper amphibolite facies of the Denna Lake Structural Complex is not a favourable setting for this type of gold occurrence.

Description of Occurrences

GOLD OCCURRENCE (WELLS) (6)

Lots 2 to 10, Concessions 8 to 11, Digby Township A previously unreported gold occurrence is located in Digby

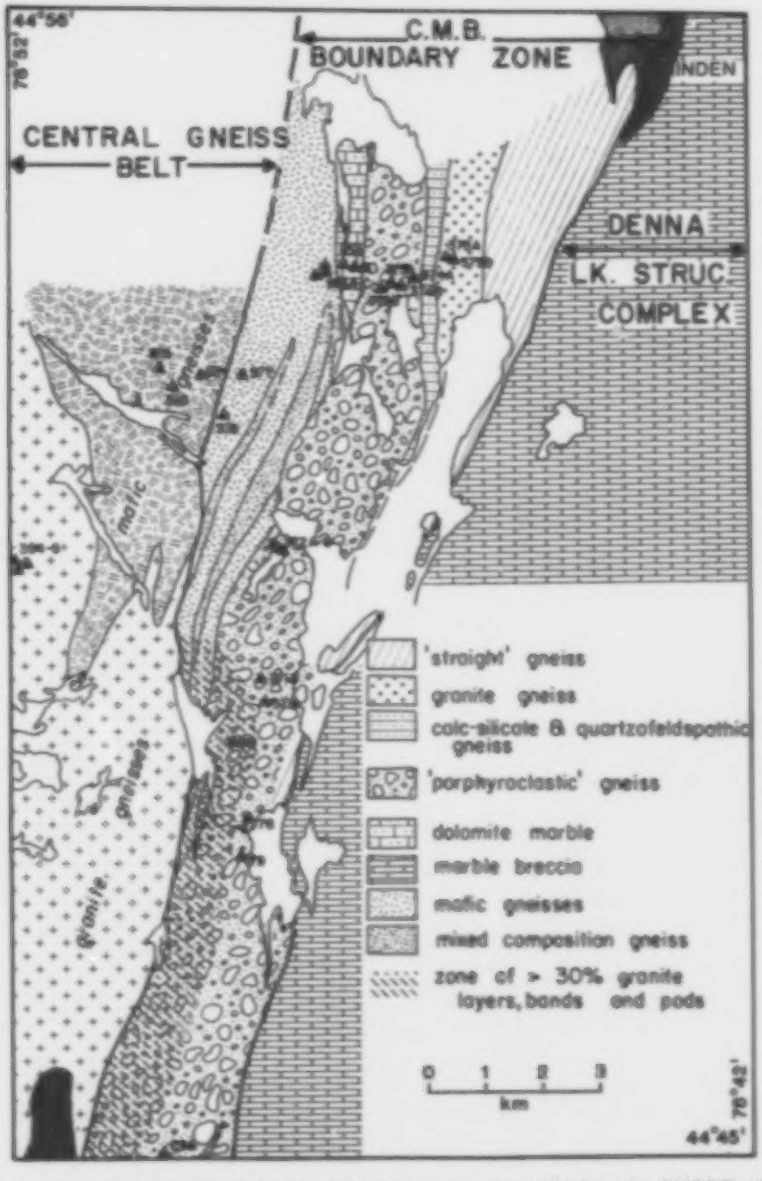
44°56'
78°52'
C.M.B.
BOUNDARY ZONE
MINDEN
CENTRAL GNEISS
BELT
DENNA
LK. STRUC.
COMPLEX
mafic
gneisses
granite
gneisses
'straight' gneiss
granite gneiss
calc-silicate & quartzofeldspathic gneiss
'porphyroclastic' gneiss
dolomite marble
marble breccia
mafic gneisses
mixed composition gneiss
zone of > 30% granite layers, bands and pods
0 1 2 3
km
78°42'
44°45'

Figure 24. Location of assay samples for gold collected by field party personnel in 1984 from the CMBBZ. All samples assayed less than 0.01 ounce per ton gold (< 0.34 ppm). Numbers refer to sample locations.

Township west of Sheldon Lake, within the area bounded by lots 2 to 10, concessions 8 to 11 (I. Wells, pilot and prospector, Head Lake, personal communication, 1984; B. Kulas, prospector, Minden, personal communication, 1985). This area is underlain by older mafic gneisses (unit 1) of the Fishog subdomain. Field party personnel were unable to locate the occurrence because of heavy vegetation growth in the area since the discovery of gold over 30 years ago. The rocks here are lithologically consistent with a possible gold occurrence. Five assay samples collected by field party personnel from the general area of the reported occurrence yielded gold values of less than 0.01 ounce per ton gold (< 0.34 ppm).

IRON

Magnetite is common as an accessory mineral in syenite and syenogranite pegmatites within the Denna Lake Structural Complex, locally accounting for up to 10 to 15 percent of the rock. It is commonly associated with radioactive minerals. These occurrences are too small to be of much economic interest, but may be of interest to collectors. The presence of these local magnetite concentrations should be borne in mind when interpreting the results of detailed magnetic surveys in the area.

MOLYBDENUM

Two occurrences of molybdenum have been identified in the Digby–Lutterworth area and are described below. Within the Denna Lake Structural Complex, disseminated crystals of molybdenite are present in calcite marble breccia at Miners Bay, in calcite marble along the Buller Road near the southern boundary of the map area, and on lots 22 and 23, concession 5, Lutterworth Township (occurrence 17 and 18, described below). Locally, it is concentrated into small veins or stringers of relatively pure molybdenite, such as on lot 7, concession 10, Lutterworth Township (Parsons 1917). Molybdenite is present only in calcite marbles adjacent to deformed and cataclastic granite to syenite pegmatite veins. At Shadow (formerly Mud Turtle) Lake, within the extension of the Denna Lake Structural Complex south of the map area (Figure 25), molybdenite also occurs in marbles associated with pegmatites; the Horscroft Mine (trench) produced 33 t of 2 percent MoS_2 ore in 1916, yielding 395 kg of molybdenum (AFRO). Rio Tinto (Canada) Limited in the period 1956 to 1957 reported an ore grade of 4.56 percent MoS_2, and Texas Kidd Mining Corp. Ltd. in 1965 reported an ore grade of 4.05 percent (averaging 3.67 percent MoS_2 over 2 m) from the same property (AFRO). L. Horscroft also reported molybdenite as disseminated flakes from lot 3, concession A, Somerville Township, on the north shore of Shadow Lake (Satterly 1943). A grab sample showing visible MoS_2 collected by field party personnel on Highway 503, 3.25 km east of Norland on the north shore of Shadow Lake (less than 1 km south of the map area), contained 7300 ppm Mo (1.2 percent MoS_2) and indicates that molybdenum mineralization may extend into the map area, particularly since this showing is on strike with the Horscroft Mine and the Horscroft occurrence (Figure 25). The Denna Lake Structural Complex, in particular area "G" (see Figure 8), is the most favourable zone for molybdenum exploration, as indicated by the distribution of known molybdenum occurrences.

Adams and Barlow (1910) reported a molybdenite occurrence in the Fishog subdomain on lot 16, concession 7, Digby Township, in quartz diorite gneisses. Field party members were unable to locate this occurrence, nor did they observe any molybdenite occurrences elsewhere in the Fishog subdomain.

Description of Occurrences

MOLYBDENITE OCCURRENCE (5)

Lot 16, Concession 7, Digby Township Adams and Barlow (1910) reported visiting a molybdenum mine (their term) located on lot 16, concession 7, Digby Township. They described the occurrence as follows:

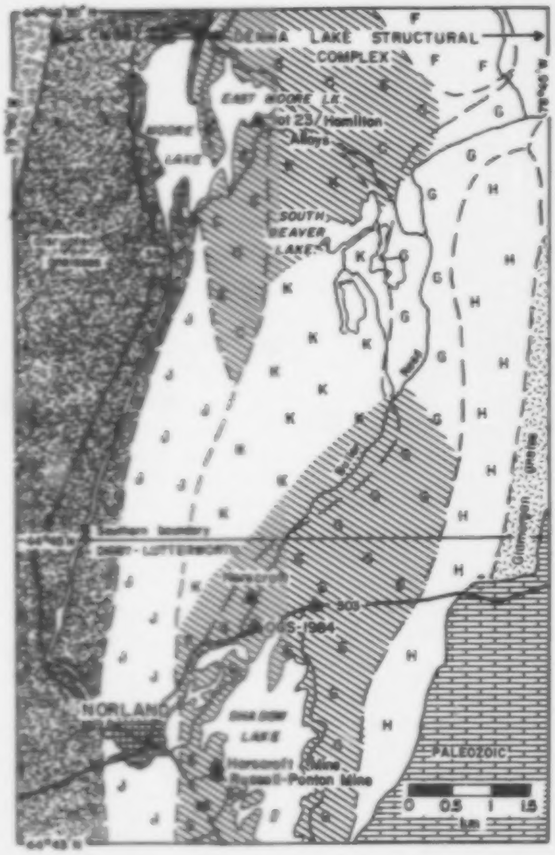

Figure 25. Sketch map showing the distribution of molybdenite occurrences (filled triangles) in the Digby–Lutterworth and adjacent Shadow Lake areas. Diagonally ruled pattern indicates areas most favourable for molybdenum, based on the present geological survey and the distribution of known molybdenite occurrences. Units within the Denna Lake Structural Complex are the same as in Figures 8 and 9.

> "The mineral was found to occur as a little string, five inches (11.2 cm) in length and an inch and a half (3.5 cm) wide in quartzose grey gneiss, and was therefore of no economic value. The mineral, however, is pure and of good quality."

Field party personnel were unable to locate this occurrence in 1984; however, extensive forest cover and flooding in the area may have served to cover the occurrence. The site would be located in quartz diorite gneiss of unit 7 (Map 2530, back pocket).

MOLYBDENITE OCCURRENCE (17, 18)

Lots 22 and 23, Concession 5, Lutterworth Township Adams and Barlow (1910) reported that a small amount of molybdenite was found on lot 23, concession 5, Lutterworth Township, as disseminated flakes in marble. Field party personnel located a small trench in the area containing molybdenite, and disseminated molybdenite occurred in marble outcrops on lots 22 and 23, concession 5, Lutterworth Township, near the shore of East Moore Lake. The trench is relatively free of vegetation, and was probably made or cleared out sometime after the visit by Adams and Barlow to the area.

A second, possibly related or the same, occurrence was reported from lot 23, concession 5, Lutterworth Township, by Satterly (1943). He reported that between 1916 and 1917, Hamilton Molybdenum Alloys Company Limited was said to have dug a shaft 2 by 4 by 10 m deep for the purpose of extracting molybdenite. In 1942, Satterly (1943) reported that the shaft had caved in, and the dump contained biotite-poor, quartz-rich granite gneiss with epidote-tremolite inclusions and minor pyrite. Satterly (1943) did not observe any molybdenite.

Hans Lundberg in 1954 reported minor radioactive mineralization near the molybdenite pits in 1954 (AFRO; *see description of occurrence 16 in* "Radioactive Mineralization").

RADIOACTIVE MINERALIZATION

Several occurrences of radioactive minerals associated with late to posttectonic pegmatite dikes occur within the map area, all located within the Denna Lake Structural Complex and associated with gamma ray spectrometric highs (Figure 19). Several airborne radiometric surveys have been conducted in the area, and are briefly described below.

- Hans Lundberg, 1954 (AFRO) surveyed 333 km² of Lutterworth and the northwestern part of Somerville townships in an 8 km wide swath extending from the north end of Gull Lake to Norland.
- Jorex Ltd., 1978 (AFRO), surveyed most of Lutterworth Township east of Gull Lake.
- The Ontario Geological Survey (1978) surveyed the Digby–Lutterworth area at a scale of 1:250 000 as part of a regional survey covering the Lake Simcoe region.
- The Geological Survey of Canada (1984a) surveyed the Digby–Lutterworth area at a scale of 1:50 000 as part of a Minden–Haliburton area survey.

These surveys outlined a number of radioactive mineral occurrences in the eastern third of the map area. Lundberg outlined all of the known occurrences in 1954 (AFRO). Some of these occurrences were examined in detail by Jorex Ltd. in 1978 as described below.

Radioactive minerals disseminated in marbles have not been found within the map area, although they may be present as both Lundberg and Jorex Ltd. located uranium and thorium occurrences in marbles on the north shore of Shadow Lake, about 1 to 2 km south of the southern boundary of the map area (AFRO). The relevant assay values are:

- 0.24 weight percent U_3O_8 (Lundberg 1954, AFRO)
- 0.429 weight percent U_3O_8, highest value; 0.063 weight percent U_3O_8 average value (Jorex Ltd. 1978, AFRO)
- 0.090 and 0.010 weight percent U_3O_8, grab samples collected in 1984 by field party personnel on Highway 503, adjacent to the Jorex Ltd. property

Future exploration for radioactive minerals in the area should concentrate on areas showing significant gamma ray spectrometric anomalies.

Description of Occurrences

ARBUCKLE (11)

Lot 22, Concession 4, Lutterworth Township Between 1956 and 1957, F. Arbuckle stripped, trenched and drilled a radioactive pegmatite on lot 22, concession 4, Lutterworth Township. A total length of 26 m was drilled over three holes (AFRO). The holes were in a syenitic pegmatite containing appreciable amounts of magnetite. A scintillometer survey in the area of Arbuckle's trenches, which are only partly overgrown, recorded an intensity of 20 000 counts per second (cps) combined uranium and thorium. Grab samples from the trench contained 780 and 490 ppm thorium, and 0.040 and 0.020 weight percent total radioactivity expressed as weight percent U_3O_8. The occurrence lies in an area with a significant gamma ray spectrometric anomaly, and future exploration in the area, particularly in nearby marbles, may be warranted.

H. LUNDBERG (16)

Lot 22, Concession 5, Lutterworth Township This occurrence was located during an airborne radiation survey conducted in 1954 by H. Lundberg, in the area between Gull Lake and Norland. One sample collected by Lundberg from near the old molybdenite pit near East Moore Lake (occurrences 17 and 18) ran 0.15 weight percent U_3O_8 (AFRO). A sample was also obtained from the east end of Beaver Lake by Lundberg, and ran 1.0 weight percent U_3O_8 (AFRO). This ground was later acquired by Jorex Ltd. in 1978 (occurrence 8, described below). A sample collected by Lundberg from the Norland–Dongola area contained 0.24 weight percent U_3O_8 (AFRO). This property was acquired by Jorex Ltd. in 1978.

JOREX LTD. (8)

Lot 22, Concession 3, Lutterworth Township As noted above, this occurrence was acquired by Jorex Ltd. (name changed to Canadian Jorex Limited in 1984) in 1978, following an airborne radiation survey of Lutterworth Township by the company (AFRO). The area had previously been examined by Hans Lundberg in 1954, who reported an assay value of 1.0 weight percent U_3O_8 from a sample taken in the area (AFRO). Field party personnel examined the site in 1984 and located several diamond-drill holes that had been made in syenitic pegmatitic and quartzofeldspathic schists (siliceous clastic metasedimentary rocks), presumably by Jorex Ltd. No assessment work is on file for this property, however. A scintillometer survey of the property was made by field party personnel in 1984, who noted intensities of 20 000 to 40 000 cps from uranium and thorium on the property. The property is near a cottage site on South Beaver Lake.

E.T. HOGAN (23)

Lot 11, Concession 6, Lutterworth Township Hewitt (1967) noted that allanite, thorite and uranothorianite had been reported from a pegmatite at this location. Field party personnel were unable to locate the occurrence, but this lot lies near the western margin of the Glamorgan Gneiss Complex, in an area containing abundant granitic and syenitic pegmatites. No other details are known about this locality.

SULPHIDE MINERALIZATION

A variety of sulphide occurrences are present in the map area, and can be divided into three main types: 1) zinc sulphides in dolomite marbles; 2) a variety of sulphide minerals, mainly pyrite, pyrrhotite, chalcopyrite and sphalerite in marbles and siliceous clastic metasedimentary rocks; and 3) similar occurrences to "2", but consisting only of rusty weathering, pyrite- and pyrrhotite-bearing siliceous clastic metasedimentary rocks. Most of these occurrences are present in the Denna Lake Structural Complex, although a 1 km long gossan zone is present in granitic rocks of the Fishog subdomain about 2 km east of Long Lake on lot 9, concessions 5 and 6, Digby Township. Samples were collected by field party personnel from this gossan for analysis, but no anomalous values were noted for As, Co, Cu, Mo, Ni, Pb, Ti, Zn or total radioactivity.

The first category consists of several occurrences, mainly located in the Buller Lake area and underlain by dolomite marble. This area was explored by St. Joseph Explorations Ltd. in 1976 and 1981 (*see description of occurrence 10*; AFRO). Areas rich in dolomite marble within the Denna Lake Structural Complex are shown in Figures 4 and 8, and are the most favourable exploration targets for zinc minerals in the map area.

The second category consists of a number of scattered occurrences, located by field party personnel through assay sampling of rusty weathering, carbonate and siliceous clastic metasedimentary rocks. These deposits are not restricted to any particular zone within the Denna Lake Structural Complex. Given the brecciated character of this complex, the individual extent of these occurrences may be small. However, most sampling was restricted to rusty weathering schists exposed along existing roads and highways, in part because these units are not well exposed in the bush, and hence may not truly reflect the sulphide mineral potential of the area.

The third category consists of several occurrences, all in rusty weathering siliceous clastic metasedimentary rocks, which are barren of sulphide minerals apart from pyrite and pyrrhotite. There is no apparent selective geographic distribution of these occurrences within the Denna Lake Structural Complex. Two of these occurrences are associated with graphite (occurrences 15 and 22) and are described under that section of this report.

In 1954, Lundberg reported that an assay sample collected on the west side of Beaver Lake ran 0.05 percent (500 ppm) columbite (AFRO). The precise location from which this sample was taken is unknown to the author. Lundberg reported that the sample was hosted by "paragneiss". This part of South Beaver Lake is underlain by siliceous clastic metasedimentary rocks. Siliceous clastic metasedimentary rocks with high niobium and zirconium contents are present 200 m east of Highway 35 at Minden between Highway 121 south and Highway 121 north, and perhaps a similar unit near South Beaver Lake accounts for the showing of Lundberg.

An assay sample collected from lots 11 to 13, concession 6, Lutterworth Township, by field party personnel in 1983 contained over 1400 ppm arsenic. No gold was detected in the sample. Background levels of arsenic in the area are less than 15 ppm, so this is a considerable enrichment.

Little sulphide mineralization was observed in either the CMBBZ or the Fishog subdomain apart from the aforementioned gossan zone.

Description of Occurrences

ZINC OCCURRENCE (10)

Lots 19 to 23, Concession 4; Lots 15 to 18, Concession 5; Lot 17S, Concession 6; Lutterworth Township St. Joseph Explorations Ltd. examined these lots in 1976 and 1981 during the course of an exploration program for zinc in the western part of the Central Metasedimentary Belt. In 1976, St. Joseph Explorations Ltd. conducted magnetometer, very low frequency electromagnetic (VLF-EM) and induced polarization (IP) surveys over Buller Lake, and located one anomalous zone. In 1981, St. Joseph Explorations Ltd. examined the other lots west and south of Buller Lake by magnetometer and VLF-EM surveys and reported some anomalous zones near Sam's Lake (AFRO). This is an area containing known graphite (occurrence 14), and this may account for some of the observed anomalies. No other assessment work has been filed on this property. Most of this area is underlain by dolomite marble, and locally field party personnel have observed sphalerite crystals in outcrop. The occurrences are small, and consist only of a few small crystals.

COPPER OCCURRENCE (13)

Lot 15S, Concession 5, Lutterworth Township This occurrence is located in impure calcite marbles and calc-silicates adjacent to the Buller Lake road on lot 15S, concession 5, Lutterworth Township. A sample collected by field party personnel and assayed contained 250 ppm copper. No other anomalous metal values were noted. Background levels of copper in the Denna Lake Structural Complex are 50 ppm.

ZINC OCCURRENCE (12)

Lot 15N, Concession 5, Lutterworth Township A calc-silicate schist on lot 15N, concession 5, Lutterworth Township, collected by field party personnel for assay contained 185 ppm zinc. Background levels of 80 ppm or less are common in the Denna Lake Structural Complex.

PYRRHOTITE, ARSENIC OCCURRENCE (19)

Lots 11 to 13, Concession 6, Lutterworth Township A dolomitic calcite marble from lots 11 to 13, concession 6, Lutterworth Township, containing pyrrhotite was also found to contain over 1400 ppm arsenic. Background levels of arsenic are 10 ppm or less within the Denna Lake Structural Complex. This site is on the eastern boundary of the map area, and the occurrence was also noted in Easton (1987a).

LEAD OCCURRENCE (21)

Lot 18, Concession 6, Lutterworth Township An assay sample collected by field party personnel from a siliceous clastic metasedimentary rock on lot 18, concession 6, Lutterworth Township, contained 290 ppm lead. Background levels for lead in the Denna Lake Structural Complex are less than 15 ppm. This site is located near Miners Bay.

COBALT, COPPER, ZINC, NICKEL OCCURRENCE (24)

Lot 15, Concession 7, Lutterworth Township A roadcut on Highway 35 on lot 15, concession 7, Lutterworth Township, exposes about 15 m of rusty weathering siliceous clastic metasedimentary rocks and marbles with calc-silicate layers within the Denna Lake Structural Complex. A sample from the west side of the outcrop from a calc-silicate layer containing about 3 percent visible pyrite contained 44 ppm cobalt, 225 ppm copper and 300 ppm zinc on assay. A sample from a rusty weathering siliceous metasedimentary rock from the east side of the highway cut contained 44 ppm cobalt, 142 ppm copper, 188 ppm nickel and 160 ppm zinc on assay. Background levels for these elements in the Denna Lake Structural Complex are 20 ppm cobalt, 50 ppm copper, 30 ppm nickel and 80 ppm zinc.

ZINC OCCURRENCE (25)

Lot 14, Concession 8, Lutterworth Township This occurrence was located by field party personnel and is hosted in rusty weathering marbles and siliceous clastic metasedimentary rocks exposed in a roadcut on Highway 35 on lot 14, concession 8, Lutterworth Township. Assay values of 230 ppm, 190 ppm and 112 ppm zinc were reported for three samples collected at this site. Background levels for zinc in the Denna Lake Structural Complex are less than 80 ppm. No other anomalous metal values were found in the samples collected at this site. This occurrence may not be extensive, as dolomitic marbles are not common in this part of the Denna Lake Structural Complex.

ZINC, PYRITE OCCURRENCE (26)

Lot 12, Concession 9, Lutterworth Township This occurrence is in a rusty weathering marble exposed in a roadcut on the west side of Highway 35 on lot 12, concession 9, Lutterworth Township, about 500 m northeast and along strike with the zinc occurrence at site 25. An assay sample collected by field party personnel recorded a value of 270 ppm zinc. No other anomalous metal values were reported from this sample.

COBALT, COPPER, ZINC OCCURRENCE (27)

Lots 2 and 3, Concession B, Somerville Township This occurrence is located near the site of an area of relatively pure calcite marbles on lots 2 and 3, concession B, Somerville Township, near the southern boundary of the map area. An assay sample collected by field party personnel from a rusty weathering calcite marble adjacent to the cleaner marbles returned values of 325 ppm cobalt, 1290 ppm copper and 200 ppm zinc. Background levels for these elements in the Denna Lake Structural Complex are 20 ppm, 50 ppm and 80 ppm, respectively.

NONMETALLIC MINERALIZATION

GRAPHITE

Several minor occurrences of graphite (1 to 2 percent of the rock) have been identified within the map area, and are described below. In all cases, the graphite occurs as 1 to 3 mm sized flakes in coarse-grained (3 to 5 mm) calcite marbles and associated rusty weathering, siliceous clastic metasedimentary rocks. All occurrences lie along, or near, the margin of a large block or area of dolomite in the Denna Lake Structural Complex centred near Buller Lake (Figure 26). It is possible that this localization of graphite occurrences is due to the migration of carbon from possible organic structures (algal mat stromatolites) within the dolomite block, or, it is related to faulting and shearing along the margins of the block. Whatever the origin of the occurrences, the area around Buller Lake is the most favourable region for further exploration for graphite. Although the known occurrences are small, they may be indicators of larger graphite deposits in the area.

Another potential area for graphite exploration is along the margin of the Glamorgan Gneiss Complex with the Denna Lake Structural Complex. This is an area of known faulting (Easton 1987a), and as such, may be expected to be graphitic over part of its length.

Description of Occurrences

GRAPHITE OCCURRENCE (9)

Lot 15, Concession 4, Lutterworth Township Adams (1894, p.8-J) and Adams and Barlow (1910) reported abundant graphite in marbles on lot 15, concession 4, Lutterworth Township. Field party personnel were unable to locate this occurrence, and it may be overgrown. This occurrence is marginal to the Buller Lake dolomite block (Figure 26).

GRAPHITE OCCURRENCE (14)

Lot 19, Concession 5, Lutterworth Township Field party personnel noted about 1 percent graphite in dolomite marble along the shore of Otter Lake on lot 19, concession 5, Lutterworth Township. A grab sample collected by field party personnel contained 0.7 percent noncar-

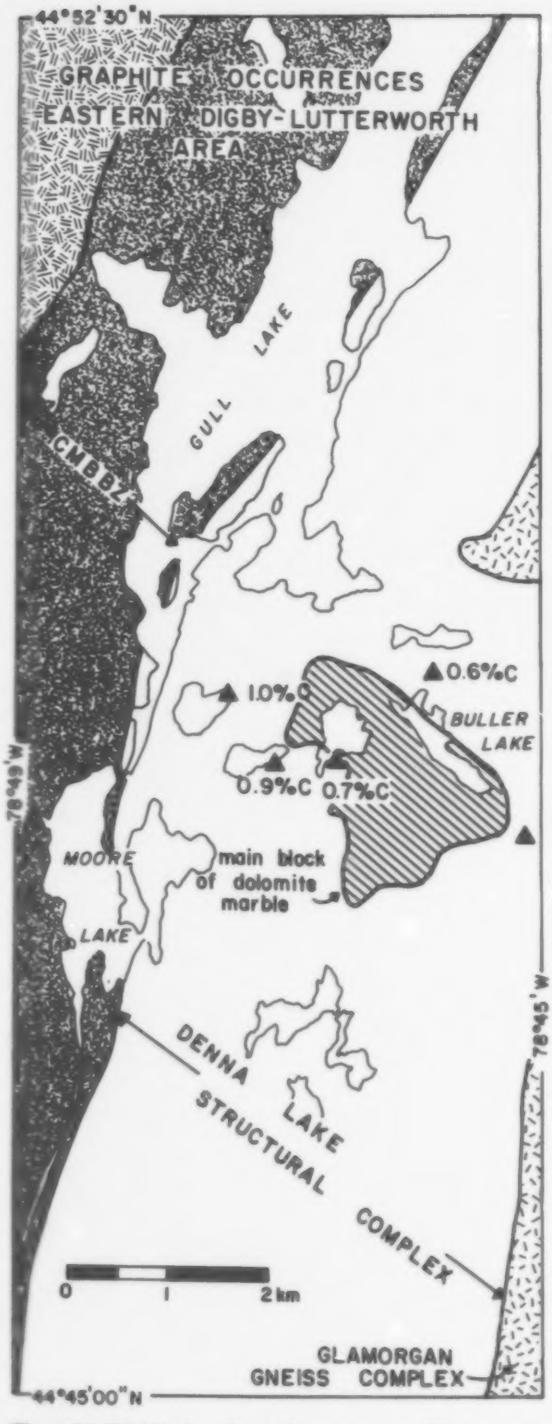

Figure 26. Distribution of graphite occurrences (filled triangles) in the eastern part of the Digby–Lutterworth area. All known occurrences are marginal to a large block of dolomite marble at Buller Lake. Percentage of noncarbonate carbon of the occurrences is shown on the map where data are available.

bonate carbon, an approximation of the graphite content of the sample. This occurrence is marginal to the Buller Lake dolomite block (Figure 26).

GRAPHITE, PYRITE, PYRRHOTITE OCCURRENCE (15)

Lot 20, Concession 5, Lutterworth Township A graphite-bearing calcite marble about 15 m thick is intercalated with two 5 to 15 m thick layers of rusty weathering, siliceous clastic metasedimentary rocks containing pyrite and pyrrhotite on lot 20, concession 5, Lutterworth Township. This occurrence was discovered by field party personnel. A grab sample from the marble contained 0.9 percent noncarbonate carbon, an approximation of the graphite content of the sample. Grab samples from the siliceous clastic metasedimentary rocks both above and below the marble were analyzed for Ag, As, Au, Co, Cu, Fe, Mo, Pb, Th, Ti and Zn. There were no anomalous or otherwise significant values in the samples. This occurrence is marginal to the Buller Lake dolomite block (Figure 26).

GRAPHITE OCCURRENCE (20)

Lot 16, Concession 6, Lutterworth Township Field party personnel noted 1 to 2 percent graphite in marble breccia on the south side of the Buller Lake Road. A grab sample submitted for assay contained 0.6 percent noncarbonate carbon, an approximation of the graphite content of the sample. This occurrence is marginal to the Buller Lake dolomite block (Figure 26).

GRAPHITE, PYRITE, PYRRHOTITE OCCURRENCE (22)

Lot 21, Concession 6, Lutterworth Township Field party personnel located a graphite-bearing marble about 15 m thick intercalated with rusty weathering, siliceous clastic metasedimentary rocks containing pyrite and pyrrhotite on the northeast shore of Sludge Lake on lot 21, concession 6, Lutterworth Township. The geologic setting is similar to that at occurrence 15 (see above). The graphite content of the marble is estimated at 1 percent noncarbonate carbon. This occurrence is marginal to the Buller Lake dolomite block (Figure 26).

MARBLE

Marble is abundant throughout the eastern third of the Digby–Lutterworth area, and may be potentially useful as building and crushed stone, and as a refractory material for industry (*see* Springer 1983). Despite its overall brecciated nature, large areas of relatively pure calcite and dolomite marble are present in the Denna Lake Structural Complex, and a wide variety of marble types is represented. As noted by Springer (1983), relatively pure dolomite marbles have the greatest potential as an industrial mineral. The distribution of dolomite marbles in the Digby–Lutterworth area is shown on Figures 4 and 8. The proximity of pure dolomite marbles to tremolite-bearing marbles of dolomite composition also means that both commodities could be mined together in parts of the area.

TABLE 18. PARTIAL CHEMICAL ANALYSES OF MARBLES FROM THE DIGBY–LUTTERWORTH AREA. SEE FIGURE 27 FOR SAMPLE LOCATIONS.

(wt. %)	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2	1.0	0.6	2.9	2.0	5.56	15.5	3.1	1.2	0.6	5.46	5.84	ND
Al_2O_3	0.2	0.2	0.2	0.1	0.06	0.2	0.2	0.2	0.1	0.64	0.62	1.11
Fe_2O_3	0.19	0.04	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.08	9.52	0.55
FeO	0.73	0.51	1.02	0.22	0.15	0.22	0.42	0.22	0.22	0.36	1.96	0.58
MgO	19.7	19.6	20.6	20.7	21.9	18.3	2.4	2.0	0.6	6.08	18.6	21.4
Al_2O_3	0.2	0.2	0.2	0.1	0.06	0.2	0.2	0.2	0.1	0.64	0.62	1.11
Fe_2O_3	0.19	0.04	0.17	0.0	0.0	0.0	0.0	0.0	0.0	0.08	9.52	0.55
FeO	0.73	0.51	1.02	0.22	0.15	0.22	0.42	0.22	0.22	0.36	1.96	0.58
MgO	19.7	19.6	20.6	20.7	21.9	18.3	2.4	2.0	0.6	6.08	18.6	21.4
CaO	28.3	28.4	26.8	28.6	28.4	29.5	51.0	52.1	54.0	44.9	42.6	23.4
CO_2	46.9	47.7	45.3	46.5	42.3	34.6	42.8	44.6	44.9	40.3	34.9	ND
(ppm)												
As	--	--	--	--	ND	--	--	--	--	--	--	--
Cu	6	6	6	6	8	10	8	8	10	16	250	ND
Mo	--	--	--	--	--	--	--	--	--	--	--	10
Pb	14	20	ND	--	11	--	--	13	--	--	--	ND
Sr	55	50	35	130	210	150	105	285	165	130	190	ND
Zn	125	190	20	24	32	39	16	14	14	32	58	ND
(ppb)												
Au	--	--	--	--	ND	--	--	--	--	2	16	ND
CaO/MgO	1.4	1.45	1.3	1.4	1.3	1.6	21.25	26.1	90	7.4	1.3	1.1

Notes:

1. *84-RME-0016B, pure dolomite, Haliburton County Road 2, 1 km north of map area*
2. *84-RME-0016C, as above, but containing minor disseminated sulphides*
3. *84-RME-0016D, as 16B*
4. *84-RME-0133B, dolomite marble, Highway 503, east of Norland*
5. *84-RME-0113C, dolomite marble, minor quartz, Highway 503, east of Norland*
6. *84-RME-1027, impure marble, graphite bearing, near Buller Lake*
7. *84-RME-1037, impure calcite marble contining garnet and diopside*
8. *84-RME-1105, pure calcite marble, near Buller Lake road*
9. *84-RME-1110, pure calcite marble, near Buller Lake road*
10. *84-RME-1052, impure marble with disseminated graphite, Otter Lake*
11. *84-RME-1063, sulphide-rich calcite marble*
12. *84-RME-0138, dolomite marble, pure but with minor fuchsite, Highway 503 near Norland*

--: not detected
ND: not determined

No marble quarries have operated in the map area, although several marble occurrences were described by Adams and Barlow (1910) as being suitable for building and crushed stone. No systematic effort has yet been made to evaluate the industrial mineral potential of marbles within the map area, so the descriptions below may only reflect some of the potential of the area. Partial analyses of marbles in the area performed on samples collected by field party personnel are given in Table 18, and illustrate the purity of some of the marbles in the map area.

Description of Occurrences

MARBLE OCCURRENCE (3)

Lot 16, Concessions 4 and 5; Lot 19, Concessions 4 and 5; Lot 20, Concession 5; Lutterworth Township Adams and Barlow (1910) reported the presence of a serpentine-bearing marble on lot 16, concessions 4 and 5, Lutterworth Township. Adams (1894) and Adams and Barlow (1910) also reported relatively pure coarse crystalline marbles on lot 19, concessions 4 and 5, and lot 20, concession 5, Lutterworth Township. They described these marbles as fine material for building stone, but as rather coarse-grained for very fine work or statuary purposes. These lots are in the area underlain by dolomite marble on the south shore of Buller Lake, and as such represent a large source of marble near to existing road networks.

DOLOMITE OCCURRENCE (7)

Lot 26, Concession 1, Lutterworth Township Field party personnel located a relatively pure dolomite marble on lot 26, concession 1, Lutterworth Township, adjacent to a large, north-trending ridge of quartz arenite. A lime-silica operation might be feasible for this site.

MARBLE OCCURRENCE (27)

Lots 2 and 3, Concession B, Somerville Township Field party personnel located a relatively pure band of calcite marble on lots 2 and 3, concession B, Somerville Township, at the southern boundary of the map area. A large ridge of quartz arenite lies due north of the marble occurrence, and is also relatively pure. An analysis of a grab sample of the marble is given in Table 18, analysis 9.

SAND AND GRAVEL

Good quality sand and gravel deposits occur along the Gull River system and are glaciofluvial in origin. A few local quarries are present in these deposits, as shown in Figure 16, mainly in the vicinity of Moore Falls, on Haliburton County Road 2 and along Highway 35 between 3 and 10 km north of Norland. At present, sand and gravel deposits in the Digby–Lutterworth area are an underutilized resource.

STONE

Each of the three main tectonic subdivisions of the Digby–Lutterworth area have potential for producing different types of stone products. This category includes: building stone, road metal, flagstone, ornamental stone (ranging in composition from diorite to syenite), as well as a variety of marbles. The latter are discussed in greater detail in the preceding section on marbles. The potential of each tectonic zone is outlined below.

Denna Lake Structural Complex In addition to previously mentioned marbles, granitic rocks within the Denna Lake Structural Complex may be useful as building stone. Most granites within this zone have a uniform pink colouration, are medium to coarse grained, and have varying degrees of foliation and lineation depending on the age of the granite relative to regional deformation. Both strongly foliated and relatively undeformed varieties are present. The most extensive areas of granitic rocks are located 2 to 5 km north of Miners Bay along Highway 35 and extending to the northeast from the Highway, and 2 to 5 km east of the Gull River in the southern part of the map area along the Ontario Hydro transmission line. The proximity of these granite localities to existing road networks, and away from existing cottage sites, make these rocks favourable candidates for exploitation.

Central Metasedimentary Belt Boundary Zone (CMBBZ) This zone has the best potential for producing flagstone, and currently two producing quarries are operating in it (occurrences 1 and 2, described below). These, as well as past producing quarries, are located along Highway 35 between Minden and Carnarvon, north of the map area. The thinly to thickly layered nature and well-developed gneissosity of the rock types within the CMBBZ make it ideally suited for the production of flagstone and other veneer type products. Rocks within this zone exhibit a wide variation in colour and texture, and thus can be used for a variety of decorative purposes. For example, augen gneiss from Dorset, which is similar to that present in the map area, has been thinly slabbed and used for the production of Tiffany style lamps. Again, the existing road network in the map area makes rocks from the CMBBZ easily exploitable.

Fishog Subdomain The Fishog subdomain contains a large number of relatively homogeneous but foliated intrusions ranging in composition from diorite to granite. However, the lack of road access into this part of the map area makes it unlikely that any of these units will be exploited for stone in the near future. The most likely candidate for quarrying within the Fishog subdomain is a red granite on the north shore of Head Lake (occurrence 4).

Other Stone Paleozoic rocks of the Gull River Formation have previously been used in the production of lime and building stone (Liberty 1969). Quarries operated in the past at Dongola (1 km southeast of the southeast corner of the map area) on Highway 503, and at Coboconk, 14 km south of Norland on Highway 35 (Liberty 1969). Paleozoic strata are exposed in several places along Highway 503 near Head Lake, and on secondary roads, and could be exploited for the production of lime, crushed stone, or building stone.

Given the presence of a variety of stone types within the map area, including marbles, limestones, granites and gneisses, a stone operation could be situated in the area which could exploit all of these types for ornamental and other stone uses. Such an operation may be more viable than a single commodity operation.

Description of Occurrences

SAIKONNEN, NORLAND, PERCY, MACDONALD (1)

Lots 26E and 26W, Concession 7; Lot 25, Concession 8; Lutterworth Township Hewitt (1964, p.25-26) described the quarry on lot 26, concession 7, Lutterworth Township, as follows:

> "A small granite gneiss quarry was operated in 1963 by Kalle Saikonnen on lot 26, concession VII, Lutterworth Township. The quarry is on the south side of the Black Lake road, a mile (1.6 km) west of Highway 35. Pink granite gneiss strikes N70E and dips 25°NW. Foliation is rather poor, but there is a lineation. Rubble and veneer are produced."

Martin (1983, p.106) reported that the quarry was 1 m deep by 3 m wide by 12 m long, and that 130 tons of flagstone was removed, in the form of slabs ranging from 15 cm to 1 m thick. Martin also stated that two smaller adjacent pits produced about 40 tons of flagstone each (Norland Occurrence, lot 26W, concession 7, Lutterworth Township; and Percy Occurrence, lot 25, concession 8, Lutterworth Township).

Field party personnel located all three quarries in 1984. Although not observed in operation, freshly broken surfaces were observed, and piles of flagstone were present at the main quarry. Rubble was apparently being removed from the site as well. The quarry is now operated by a Mr. Macdonald and produces flagstone on a demand basis only (Meyn 1985).

The material being quarried is a leucocratic, fine- to medium-grained granite gneiss, present as 15 cm to 3 m thick sills within porphyroclastic gneiss of the CMBBZ (units 25 and 26). This material occurs mainly along the east shore of Black Lake. The quarry could be considerably expanded if a suitable market for this material could be found.

FLAGSTONE QUARRY (2)

Lot 10, Concession 10, Laxton Township A quarry producing flagstone was observed by field party personnel to be in operation in 1984 on lot 10, concession 10, Laxton Township. The author does not know the identity of the owner(s) of the property, or of the operator(s) of the quarry.

The quarry is about 15 m wide by 150 m long, and is in essence a surface strip operation, as no vertical rock surfaces are exposed in the area. Overburden is removed, and the exposed outcrop surface is blasted. The suitable flagstone is stacked and removed, and the rubble is left in place. The quarry is gradually being extended north along strike with the gneissosity of the country rock. The quarry is mining well-layered, porphyroclastic to well-transposed gneiss of the CMBBZ (unit 25). This material produces stone with a wide variation in colour (grey, pink, red, black, white) and which breaks easily along gneissosity. The rock is also well lineated.

GRANITE OCCURRENCE (4)

Lots 17 to 20, Concession 1, Digby Township An occurrence of a very attractive, salmon-coloured granite was located by field party personnel on lots 17 to 20, concession 1, Digby Township. The granite is well exposed along a cottage access road on the north shore of Head Lake. Gneissosity in the granite (unit 13k) is almost horizontal. The granite is homogeneous, uniformly coloured, and is layered, mainly due to grain size variation. The rock is relatively free of cross-fractures, and should break along gneissosity into slabs. The occurrence should be further examined for use as a building or ornamental stone, and it is one of the few granites from the Fishog subdomain that is presently accessible by road.

TREMOLITE

Tremolite is a useful industrial mineral, especially if occurring with talc. Tremolite is used in the plastics industry, and as an asbestos substitute. Sizable tremolite occurrences are present in the area, and are associated with dolomite marbles in the vicinity of Buller Lake, and along the Buller Lake Road (*see* Figure 8, units F and G). The tremolite occurs as coarse-grained aggregates with 2 to 5 mm thick layers of coarse-grained quartz. A minor amount of diopside is present, but few other impurities are present in the marbles. Although quartz is a contaminant, its coarse grain size and presence as layers rather than as disseminated grains make removal of the quartz from the tremolite relatively easy. The tremolite-bearing marbles near Buller Lake are associated with possible algal mat structures in the marbles; this may be a useful field indicator for dolomitic and tremolite-bearing marbles. All tremolite deposits are well located with respect to existing roads. These occurrences are of interest to mineral collectors as well as possible commercial users.

Suggestions for Future Exploration

The present study of the Digby–Lutterworth area has shown that known mineral occurrences can be related to local geologic situations and are not randomly distributed throughout the map area. In addition, several new occurrences of metallic and nonmetallic minerals were located in the area by field party personnel (Table 17).

Conclusions with regard to the mineral potential of the area are presented below, and summarized in Figure 22 and Table 16.

METALLIC MINERALIZATION

Most metallic mineralization occurs in the Denna Lake Structural Complex. Although a tectonically disrupted terrane (as outlined in Table 16 and Figures 9 and 22), the distribution of metallic mineral occurrences within this complex is related to the regional stratigraphy prior to tectonic disruption. Of the 13 metallic mineral types recognized by Carter (1984) (Table 16) in the Central Metasedimentary Belt, stratiform zinc in dolomite marbles, metamorphic-metasomatic molybdenum, and uranium are those with the greatest potential in the map area. Stratiform magnesium, contact metasomatic iron, and hematite deposits may also be present. The other deposit types are not likely to occur. The best targets for molybdenum are in the Miners Bay area and in the southeast of the map area along the Buller Road. For zinc, the best targets are south of Buller Lake and along the Buller Road. The best target for uranium may be the area west and northwest of South Beaver Lake, where there is a large gamma ray anomaly.

The potential for metallic mineralization in the CMBBZ and the Fishog subdomain is difficult to establish. Few mineral occurrences are known in these areas, but then no exploration has been conducted in this part of the map area. The best targets are the CMBBZ for gold, and mafic gneisses in the Fishog subdomain for sulphides and possibly gold.

RADIOACTIVE MINERALIZATION

Radioactive minerals occur in several sites in the map area. Gamma ray spectrometric anomalies are a good indicator of this type of mineralization; all of anomalies in the map area are located within the Denna Lake Structural Complex. The complex is also a locus for pegmatite dike injection. Radioactive minerals have to date only been found in pegmatite dikes in the map area, although occurrences of uranium and thorium minerals disseminated within marbles is present 1 km south of the map area. Both of these types of occurrence can probably be expected within the Digby–Lutterworth area. The Denna Lake Structural Complex has previously been explored for radioactive minerals, but not all of the anomalies located during the airborne survey within the map area have been examined in detail on the ground. The best target for uranium may be the area

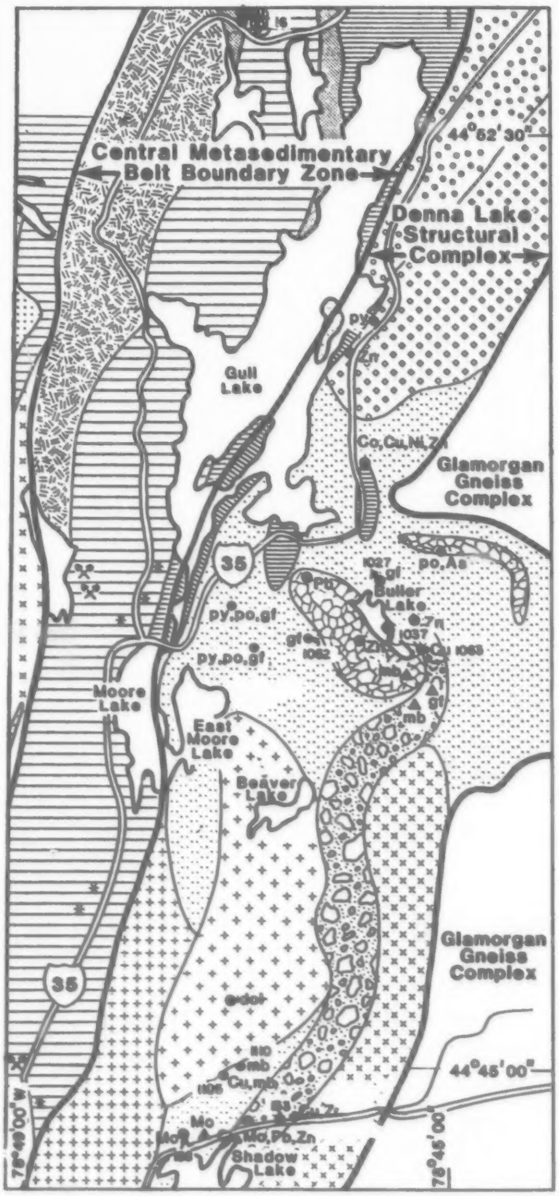
44°52'30"
Central Metasedimentary Belt Boundary Zone
Denna Lake Structural Complex
Gull Lake
py
Zn
Co,Cu,Ni,Zn
Glamorgan Gneiss Complex
35
1027
gf
po,As
Pb
Buller Lake
py,po,gf
Zn
1037
gf
1062
Zn
Cu
1063
py,po,gf
mb
gf
mb
Moore Lake
East Moore Lake
Beaver Lake
Glamorgan Gneiss Complex
35
dol
810
mb
1105
Cu,mb
Mo
Cu,Zn
Mo
Mo,Pb,Zn
Shadow Lake
44°45'00"
78°49'00"W
78°45'00"

Figure 27. Location of marble occurrences, relatively pure calcite and dolomite marbles, and location of samples chemically analyzed and reported in Table 18. Location of main areas of dolomite marbles is also indicated. Geologic contacts as in Figure 4.

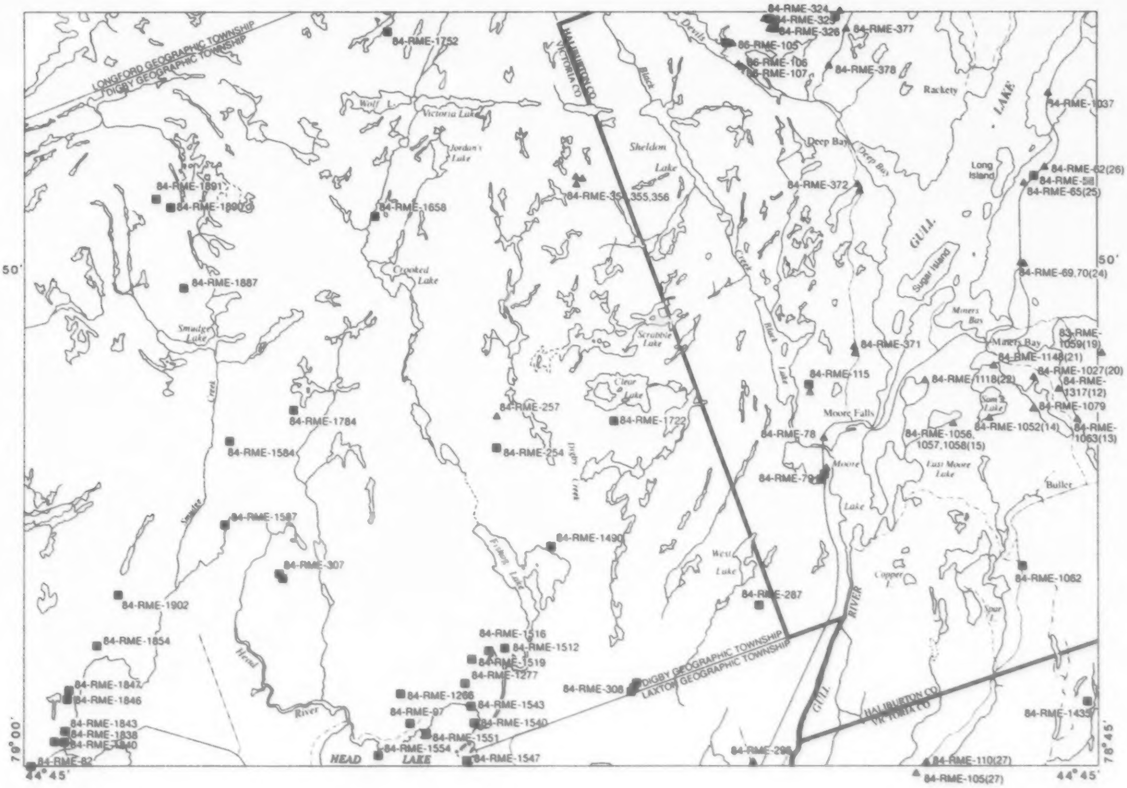

Figure 28. Location of samples for which partial (triangles) and complete (squares) chemical analyses were performed.

west and northwest of South Beaver Lake, where there is a large gamma ray anomaly.

NONMETALLIC MINERALIZATION

Marbles in the area are a potential source of building and crushed stone, refractory material for industry, and tremolite as a mineral filler. The best target areas for marbles potentially suitable for these purposes are shown in Figure 27.

Many rocks in the area are potential sources of building and ornamental stone, and two flagstone quarries are currently operating in gneisses within the CMBBZ. This zone has great potential for further production of this material. The CMBBZ and the Denna Lake Structural Complex have the greatest potential for stone production because of the existing road network.

Graphite occurrences are abundant around the dolomite marble block near Buller Lake, and further exploration may be warranted in this area.

The quartz arenites of unit 19 within the Denna Lake Structural Complex are relatively clean, and could be a source of low-grade silica for local purposes.

Rocks and Minerals For the Collector

Like much of the Grenville Structural Province, the map area hosts a variety of rocks and minerals of interest to the mineral collector. The pegmatite dikes locally contain molybdenite, magnetite, biotite, muscovite, diopside, zircon, allanite and tourmaline.

Many large crystals are present in the marble breccias of the Denna Lake Structural Complex, particularly where metamorphic reactions have occurred between the marble matrix and siliceous clasts (*see section on* "Metamorphism"). Hornblende, diopside, tourmaline, garnet, mica, hematite, graphite and molybdenite are commonly present as large, well-formed crystals. Tremolite is well developed in dolomite marbles in the Buller Lake area. Multihued varieties of serpentine are present in some of the marbles, and reflect the alteration of diopside and other mafic minerals.

Land Use Considerations

Solution features were observed in marbles in the adjacent Howland area (Easton 1987a), and may be present within parts of the Denna Lake Structural Complex. These features should be accounted for prior to construction in the area.

Most lakes and streams in the eastern third of the map area are underlain by, or drain over, marble, hence they are buffered against the effects of acid rain. Most present cottage sites and recreational areas are located within this part of the map area. The western two-thirds of the map area is underlain by granitic rocks, and are vulnerable to the effects of acid rain.

Many mineral occurrences and potential prospects are located in the Denna Lake Structural Complex. Although well served by the existing road network, many known occurrences and producing quarries are located near to existing habitation or cottage sites. Any future mineral development in the area will need to reconcile these different land uses.

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